

JOURNAL OF  
THE ROYAL SOCIETY  
OF  
WESTERN AUSTRALIA

VOLUME 53

PART 4

1970

---

REGISTERED AT THE G.P.O., PERTH FOR TRANSMISSION BY POST AS A PERIODICAL

THE  
ROYAL SOCIETY  
OF  
WESTERN AUSTRALIA

PATRON

Her Majesty the Queen

VICE-PATRON

His Excellency Major-General Sir Douglas Kendrew, K.C.M.G., C.B., C.B.E., D.S.O.,  
Governor of Western Australia

COUNCIL 1970-1971

<b>President</b>	....	....	B. J. Grieve, M.Sc., Ph.D., D.I.C., F.L.S.
<b>Vice-Presidents</b>	..	....	G. M. Storr, B.Sc., Ph.D. R. M. Berndt, M.A., Dip.Anth.(Sydney), Ph.D.(London), F.R.A.I., F.F.A.A.A.
<b>Past President</b>	....	....	P. E. Playford, B.Sc., Ph.D.
<b>Joint Hon. Secretaries</b>	.		B. Ingram, B.Sc. (Hons.) P. G. Wilson, M.Sc.
<b>Hon. Treasurer</b>	...	....	R. N. Hilton, M.A.
<b>Hon. Librarian</b>	..	....	Ariadna Neumann, B.A.
<b>Hon. Editor</b>	.	....	A. S. George, B.A. S. D. Bradshaw, B.Sc. (Hons.), Ph.D. S. J. Curry, B.Sc. A. B. Hatch, M.Sc., Dip.For. J. H. Lord, B.Sc. D. C. Lowry, M.Sc. A. J. McComb, M.Sc., Ph.D. D. Merrilees, B.Sc., Ph.D. R. T. Prider, B.Sc., Ph.D., M.Aust.I.M.M., F.G.S.

## 10.—The Australian Majid spider crabs of the genus *Achaeus* (Crustacea, Brachyura)

by D. J. G. Griffin\*

Manuscript received and accepted 17 February, 1970

### Abstract

The genus *Achaeus* is represented in Australia by eight species. *A. brevirostris* (Haswell) and *A. lacertosus* Stimpson, widespread around western, northern and eastern Australia, and the Indo-west Pacific are redescribed and figured. *A. fissifrons*, also widely distributed in the Indo-west Pacific, is recorded from Western Australia for the first time and *A. pugnax* (De Man), previously known only from Japan, is recorded from Western Australia. Three new species are described, two from eastern Australia and one from Western Australia; the identity of three small specimens of an additional species are discussed—they are not conspecific with any Australian species known at present. *A. brevifalcatus* Rathbun, known from the Seychelles, western Indian Ocean, and from Hawaii, is figured and additional descriptive notes are given.

### Introduction

The small, long-legged spider crabs of the genus *Achaeus* were reviewed by Griffin & Yaldwyn (1965) who provided a key to the Australian species known at that time and re-described *A. fissifrons* (Haswell) and commented in detail on the synonymy of the species. The key was repeated by Griffin (1966a, 1966b) and the description by Griffin (1966a). Apart from *A. fissifrons* (*A. tenuicollis* Miers), two species, *A. brevirostris* (Haswell) (*Achaeus affinis* Miers) and *A. lacertosus* Stimpson (*A. breviceps* Haswell), had been recorded from Australia up to that time. A fourth species was thought to exist in Australia but was known only from a single female from northern Queensland.

Two Danish expeditions have collected material in Australia since 1900 (Griffin, in press). The "Galathea" Expedition 1950-52 worked several stations on the shelf off southern Queensland and west of Bass Strait. Dr. Th. Mortensen's Pacific Expedition 1914-16 collected *A. fissifrons* and *A. lacertosus* from off New South Wales. Three species of *Achaeus* were collected by the "Galathea" off southern Queensland—*A. fissifrons* and two previously undescribed species, one being the "*Achaeus* sp possibly new" of Griffin & Yaldwyn.

From 1960 to 1965 staff of the Western Australian Museum, at times in collaboration with the C.S.I.R.O. Division of Fisheries & Oceanography and the Western Australian Department of Fisheries and Fauna, made numerous collections of benthic invertebrates along the Western Australian continental shelf from North West Cape to Cape Naturaliste. Four species of *Achaeus* were collected, *A. fissifrons* which had

previously been known only from eastern Australia, *A. pugnax* (De Man), previously known only from Japan, one previously undescribed species and one species of uncertain identity.

In this report, a key is provided to the eight species now known from Australia, the additional records of *A. fissifrons* are discussed and the remaining species are described and illustrated. The western Indian Ocean and Hawaiian *A. brevifalcatus* Rathbun, which is similar to one of the new species from Western Australia, is also illustrated and additional descriptive notes are given. Synonyms, including the original reference, given in the earlier paper by Griffin & Yaldwyn (1965) are not repeated here.

The material on which this report is based is deposited in the Australian Museum (AM), Queensland Museum (QM), South Australian Museum (SAM), Western Australian Museum (WAM), Universitetets Zoologiske Museum, Copenhagen (CM), Zoological Laboratory, Faculty of Agriculture, Kyushu University (ZLKU) and the United States National Museum (USNM). The number following the abbreviation of the institution's name is the registered number of the specimen(s). Terminology follows that used by Griffin & Yaldwyn (1965) and Griffin (1966a); drawings were completed with the aid of a camera lucida. Measurements were made with dial calipers to the nearest 0.1 mm; unless otherwise stated the measurement given is the carapace length. All measurements were taken as detailed by Griffin (1966a).

### SYSTEMATICS

Family MAJIDAE Samouelle, 1819

Subfamily Inachinae Macleay, 1838

Genus *Achaeus* Leach, 1817

The characters of the genus are given by Griffin & Yaldwyn (1965); the form of the pleopod in some of the species discussed here differs in some important respects from that given in that diagnosis.

\* Australian Museum, College St., Sydney, N.S.W. 2000.

# KEY TO AUSTRALIAN SPECIES OF THE GENUS *ACHAEUS*

1. Dorsal surface of carapace without spines or tubercles. Rostral lobes rounded and apically spinulate ..... *A. lacertosus* Stimpson
- Dorsal surface of carapace with two or more prominent spines or tubercles in midline and generally several laterally. Rostral lobes acute or blunt, spinulate laterally and/or medially but not apically ..... 2
- 2(1) Supraorbital eave with 1-3 large spines. Fourth ambulatory dactyls weakly curved ..... *A. fissifrons* (Haswell)
- Supraorbital eave spinulate or smooth. Fourth ambulatory dactyls falcate to semi-circular ..... 3
- 3(2) Surface of carapace with numerous spinules dorsally. Basal antennal article with spines along medial and lateral edges ..... *Achaeus* sp.
- Surface of carapace with spines or tubercles dorsally but not numerous spinules. Basal antennal article with spines or tubercles along lateral edge but not along medial edge, at least proximally ..... 4
- 4(3) Carapace with a long spine on mesogastric and cardiac regions ..... 5
- Carapace with prominent tubercles, but not spines, on mesogastric and cardiac regions ..... 6
- 5(4) Rostral lobes separated by a very narrow slit. Eyestalks short, lacking tubercles. Merus of third maxillipeds with short, subequal spinules anteromedially ..... *A. pugnar* (De Man)
- Rostral lobes widely separated by a V-shaped hiatus. Eyestalks, long, with a large tubercle anteriorly. Merus of third maxillipeds with short spines and one very long spine anteromedially ..... *A. galathea* n.sp.
- 6(4) Rostral lobes subacute. Eyestalks with two spinules on anterior surfaces. Fingers of chelae in male hardly gaping ..... *A. podocheloides* n.sp.
- Rostral lobes obtuse. Eyestalks with prominent tubercle on anterior surfaces. Fingers of chelae in male widely gaping ..... 7
- 7(6) Supraorbital eave prominently spinulate. Basal antennal article with several tubercles and spinules. Postorbital region short, unstricted in both sexes ..... *A. paradice* n.sp.
- Supraorbital eave unarmed. Basal antennal article unarmed or weakly spinulate. Postorbital region very long and constricted in male, shorter in females ..... *A. brevirostris*

## *Achaeus brevirostris* (Haswell, 1879)

Figs. 1a, 2, 15e, f

*Achaeus brevirostris*; Griffin & Yaldwyn, 1965: 46-48 (lit.), Griffin, 1966a: 38 (in key); 1966b: 276 (in key).

**Material examined:** A total of 34 specimens as follows:

Fifteen localities from Fremantle, W.A. around northern Australia to Port Jackson, N.S.W. (for further details see Griffin & Yaldwyn, 1965: 46-47), 20 ♂♂, 9 ♀♀ (6 ovig.), 6.8-12.5 mm, smallest ovig. ♀ 8.1 mm (AM).

**Western Australia.**—Five miles N. of Rottnest I., 19½ fms, 7/5/1960, R. W. George on "Davena", 1 ♂, 8.2 mm (WAM 330-67). Cockburn Sound, 9/7/1957, R. W. George on "Dante", 1 ♂, 8.8 mm (WAM 337-67). Cockburn Sound, 2 miles

W. of Naval Base, dredged, 10 fms, 22/6/1961, P. Cawthorn on "Lancelin", 1 ♀, 7.4 mm (WAM 334-67). Cockburn Sound, trawled, 10 fms, 22/4/1963, B. R. Wilson and R. J. Slack-Smith, 1 ♀ (ovig.), 9.3 mm (WAM 215-67).

**Queensland.**—Bowen Harbour before 1922, E. H. Rainford, 1 ♂, 10.5 mm (QM 146).

**Description:** Carapace elongate, length slightly more than 1½ greatest breadth, margins with a few tubercles, dorsal surface with 7-11 blunt tubercles, otherwise smooth. Branchial and cardiac regions well demarcated by broad groove from surrounding regions, regions otherwise ill-defined. Curled hairs grouped along edges of rostral spines and supraorbital eave and in groups over most of carapace.

Rostral spines moderately long, separated by narrow U-shaped hiatus in distal third, rounded apically.

Supraorbital eave unarmed. Eyestalks long and stout, a prominent tubercle midway along anterior edge, a small, blunt, sometimes obscure, tubercle opposite on ventral surface, and a prominent tubercle above cornea at distal extremity of eyestalk; cornea large, circular, obliquely subterminal.

Region between eave and hepatic region long in male, broadening regularly, constricted, short in female, broadening immediately behind eave, unconstricted.

Hepatic regions weakly inflated, laterally acute with one or two tubercles. Pterygostomial regions with a small tubercle posterolaterally and visible in dorsal view behind hepatic region.

Branchial regions swollen, bearing two small tubercles just forward of widest part of carapace. Posterolateral margins bordered by minute spinules only in small specimens, margins generally smooth in adults.

Dorsal surface of carapace with a low, broad-based tubercle far back on mesogastric region, tumid cardiac region with two blunt tubercles side by side and a low medial intestinal tubercle on posterior slope. Two small tubercles on protogastric regions laterally well forward of mesogastric tubercle. Six similar tubercles laterally on branchial regions, three on each side in a semi-circle, one anteriorly, one opposite cardiac tubercles, both small or obscure, and a large tubercle near posterior margin above base of last ambulatory leg.

Antennular fossae large, oval. Basal segment of each antennule usually bearing three or four small spinules along medial edge. Interantennular partition a narrow compressed triangular lobe.

Basal antennal articles with a few variously sized spinules usually present on surface. Antennae very long, ½ length of carapace, bearing numerous long hairs particularly on medial surface.

Epistome markedly longer than wide in male, wider than long in female, a smaller spine or tubercle just forward of, and lateral to, green gland opening.

Ischium of third maxillipeds with two oblique rows of small spines on each side of a shallow longitudinal groove; medial edge minutely toothed. Merus with about three small spines laterally beside shallow central groove; distal edge irregularly crenulate with about four small spines slightly laterally; medial edge with two

to four spines, distal ones larger. Palp long and stout, laterally, medially and apically fringed by long hairs; carpus bearing a slender spine medially near distal edge, propodus with a similar ventral spine about midway along. Exopodite smooth.

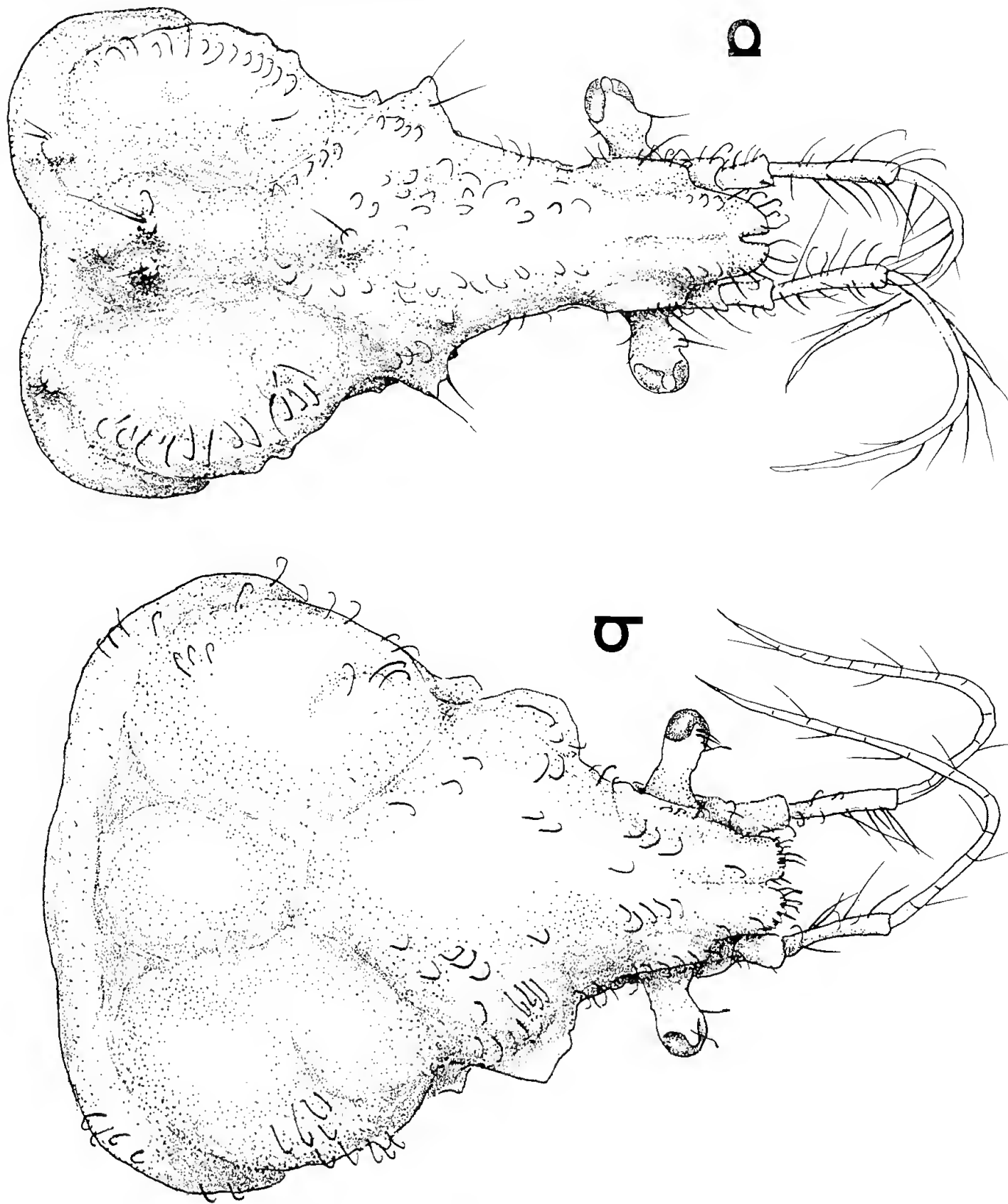


Figure 1.—a, *Achaeus brevirostris* (Haswell); Male, 11.4 mm, Port Denison, Qld (AM P.16584); carapace, dorsal view; b, *Achaeus lacertosus* Stimpson; male 10.4 mm, Port Stephens, N.S.W. (AM P.162); carapace, dorsal view.

Thoracic sternum in male with several tubercles around edge of abdominal fossa.

Chelipeds in male long and robust. Ischium subtrigonal, merus subtrigonal to subcylindrical, carpus subcylindrical, chela compressed. Merus with some small tubercles along ventromedial and ventrolateral edges and three dorsal tubercles, two proximal, one distal. Carpus with a group of tubercles proximally on dorsal

surface. Chela with palm little longer than high, sometimes with a few spinules ventrally. Fingers slightly shorter than palm, widely gaping proximally, incurved distally and acute, inner edges toothed; fixed finger with a large tooth at base, a smaller tooth sometimes mid-way along, proximal part of distal portion usually enlarged, a broad concavity separating proximal tooth from distal portion; dactyl with

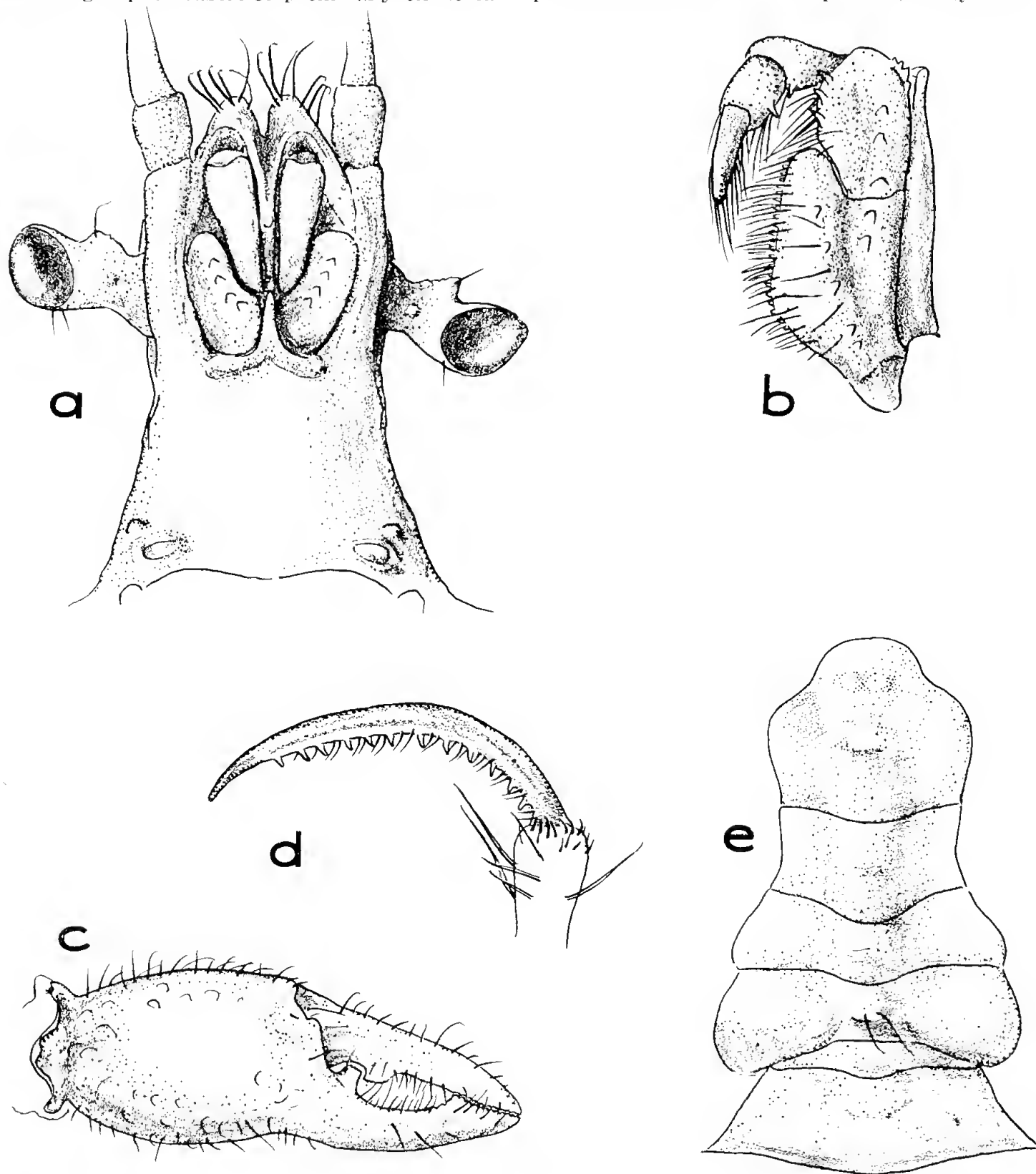


Figure 2.—*Achaeus brevirostris* (Haswell), male, 11.4 mm, Port Denison, Qld (AM P.16584). a, front of carapace, ventral view; b, left third maxilliped; c, right chela; d, left fourth ambulatory dactyl, posterior view; e, abdomen.

one large tooth distal to proximal tooth of fixed finger, a second tooth sometimes present next to this; distal parts of both fingers with irregular small teeth along adjacent inner edges. Ventromedial edge of merus, medial surface of carpus and ventral edge of chela with large and small straight hairs. Cheliped of female short, no longer than carapace, slender, merus sub-trigonal, with four to six short spines along ventrolateral edge partly obscured by long hairs, no other spines on merus, carpus and propodus lacking spines; fingers as long as palm, almost meeting along toothed cutting edges.

Ambulatory legs very long and slender, first the longest, about four times carapace length, remaining legs decreasing regularly in length, fourth the shortest, about three times carapace length; curled hairs singly along carpus and propodus dorsally. Dactyls of first two legs long and almost straight, weakly curved distally and unarmed, bearing long straight hairs; dactyls of third and fourth legs falcate, bearing short hairs and sharp recurved spines ventrally for entire length, spinules larger in distal half.

Male abdomen narrow, all segments except last wider than long, last segment the longest, slightly longer than wide. Third segment with strongly convex lateral edges, last segment sub-hexagonal, broadening in proximal half, distally rounded. Surface elevated in midline, bearing a tubercle on first segment, a wide elevation distally on third to fifth segments and on the last a central tubercle and a transverse pair of smaller tubercles not far from distal edge; third segment laterally inflated, smooth. Female abdomen broad, elongate subovate, elevated in midline.

Male first pleopod moderately slender, bulbous basally, weakly expanded and slightly outwardly curved distally, tip rounded, aperture subterminal, a long slit at end of groove extending along medial surface; three tufts of long hairs near tip, one on medial surface, one on lateral surface and one of about three hairs longer than any others arising from sternal surface and extending well beyond tip, pleopod otherwise naked.

Measurements: Male (AM P.16584): Carapace length 11.4 mm, carapace width 6.8 mm, rostrum length 1.3 mm, rostrum width 1.7 mm, cheliped length 17.5 mm, chela length 9.3 mm, chela height 3.2 mm, dactyl length 5.0 mm, first ambulatory leg length 44.0 mm, fourth ambulatory leg length 33.0 mm.

Female (ovig.) (AM P.167): carapace length 11.4 mm, cheliped length 13.0 mm, chela length 6.7 mm, chela height 2.0 mm, dactyl length 4.0 mm.

Remarks: This species was commented upon briefly by Griffin & Yaldwyn (1965) and compared with a new species from South Africa, *A. barnardi*, by Griffin (1968). Although *A. brevirostris* varies widely in carapace ornamentation and arrangement of teeth on the fingers of the male (see below) there is no doubt that it is distinct from *A. barnardi* and *A. paradisei*; the differences between *A. brevirostris* and *A. paradisei* are discussed under the latter species.

The diagnosis of *A. brevirostris* given by Griffin & Yaldwyn (1965:47) overstates the tubercles on the basal antennal article; re-examination of the Australian Museum specimens shows that there are often a few small spines or tubercles on the surface of the basal antennal article and along the outer edge; larger specimens of *A. brevirostris* generally have smooth basal antennal articles. The characteristic features of this species are the apically rounded, closely approximated rostral lobes bearing numerous curled hairs on their margins and in the males the long postorbital neck and proximally gaping fingers of the chelipeds. The arrangement of teeth on the fingers of the chelipeds in the male constitutes the most variable feature in this species. It should be noted that the general form of the male chelae, with gaping fingers and large proximal teeth is similar to that found in *A. brevifalcatus*, *A. barnardi* and *A. spinosissimus* as well as in *A. paradisei*. In *A. brevirostris*, there is generally a prominent proximal tooth on both dactyl and fixed finger and the distal teeth on the fixed finger are usually largest next to the gape. In addition, a second tooth may be present next to the proximal tooth on the dactyl and/or there may be a smaller tooth at the distal end of the gape on the fixed finger. The chela generally lacks spines but some may be present about midway along the ventral edge in small specimens. Other variable features include the shape of the rostral lobes which are sometimes short, sometimes inwardly curved distally and sometimes separated by a V-shaped hiatus; the tubercles on the lateral part of the dorsal surface of the carapace which are usually obscure in larger specimens; the number of spines on the ischium and merus of the third maxilliped; the size of the spinules on the ventral edge of the fourth ambulatory dactyls; the size of the spines and tubercles on the ventrolateral edge of the merus of the cheliped—in females there are about four short, stout spines but these are often obscured by very long hairs; and the size of the spinules along the posterolateral margin of the carapace which are present, though minute, in very small specimens but absent in large specimens. Finally, there is marked sexual dimorphism in carapace shape: in females the postorbital "neck" is not constricted and widens almost immediately behind the eye.

The smallest adult male in the present series measures 6.8 mm c.l. and the smallest ovigerous female 8.1 mm, but the largest immature male (as judged by its small chelae) is 9.1 mm.

Distribution: Western, northern and eastern Australia from Cockburn Sound to Port Jackson; Indo-west Pacific from Zanzibar (east Africa) to Indonesia; 3-30 fms.

#### *Achaeus fissifrons* (Haswell, 1879)

Fig. 13b, e

*Achaeus tenuicollis*; Teraaki, 1902: 400-401, 3 figs.

*Achaeus lorina*; Rathbun, 1911: 244 (see Griffin, 1968: 81). Not *Inachus lorina* Adams & White, 1848.

*Achaeus fissifrons*: Griffin & Yaldwyn, 1965: 38-43, figs 1-8 (lit). Griffin, 1966a: 38-41, figs 5, 19-3 & 4; 1966b: 275 (in key).

*Material examined*: A total of 22 specimens as follows:

*Western Australia*—N.W. of Pt. Cloates, 22°52'S., 113°29'E., triangle dredge, 73 fms, 6/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 178, 2 ♂♂, 1 ♀, 4.4-4.7 mm (WAM 88-67). S.W. of Pt. Cloates, 23°39'S., 113°11'E., beam trawl, 73 fms, 7/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 187, 1 ♀ (ovig.), 7.3 mm (WAM 336-67-part). N.W. of Carnarvon, 24°59'S., 112°27'E., beam trawl, 71 fms, 8/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 197, 1 ♀ (ovig.), 6.8 mm (WAM 276-67-part). N.W. of Bluff Point, 27°18'S., 113°16'E., triangle dredge, 54 fms, 9/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 204, 1 ♂, 6.3 mm (WAM 129-67). S.W. of Dongara, 29°50'S., 112°24'E., triangle dredge, 70-72 fms, 11/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 214, 1 ♂, 7.6 mm (WAM 63-67). N. of Cape Leschenault, 31°22'S., 115°03'E., triangle dredge, 47-49 fms, 11/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 217, 1 ♀ (ovig.), 7.5 mm (WAM 82-67). W. of Rottnest Island, 32°00'S., 115°16'E., beam trawl, 75-78 fms, 12/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 225, 2 ♂♂, 4 ♀♀ (3 ovig.), 5.7-7.7 mm, smallest ovig. ♀, 6.2 mm (WAM 189-67). W. of Rottnest Island, 32°03'S., 114°20'E., beam trawl, 61-74 fms, 15/2/1964, HMAS "Diamantina" Cruise 1/64, CSIRO Sta. 50, 1 ♂, 6.0 mm, 1 ♀ (ovig.), 5.5 mm (WAM 31-67). N.W. of Cape Naturaliste, 33°40'S., 114°28'E., triangle metre dredge, 75 fms, 27-28/8/1963, HMAS "Diamantina" Cruise 4/63, CSIRO Sta. 134, 1 ♀ (ovig.), 6.8 mm (WAM 332-67-part).

*Queensland*—Southern Coral Sea, 26°33'S., 153°31'E., dredged, 86 metres, gravel 5/11/1951, "Galathea" Expedition 1950-52 Sta. 539, 1 ♀ (ovig.), 5.4 mm (CM).

*New South Wales*—Disaster Bay, trawled, 30-40 fms, sand and mud, 1/10/1914, Th. Mortensen on "Endeavour", 4 ♂♂, 3 ♀♀ (ovig.), 6.8-10.5 mm, smallest ovig. ♀, 7.8 mm; N. of Montague I., 36°00'S., 150°20'E., dredged, 36-65 fms, sand and mud, 28/9/1914, Th. Mortensen on "Endeavour", 1 ♂, 7.5 mm; S. of Montague I., 37°05'S., 150°05'E., dredged, 20-50 fms, sand and mud, 30/9/1914, Th. Mortensen on "Endeavour", 1 ♂, 7.0 mm (all CM). Off Botany Bay, M. Ward, (no other data), 1 ♀ (ovig.), 9.1 mm (SAM C.1199).

*Remarks*: The description of this species given by Griffin & Yaldwyn (1965) and repeated by Griffin (1966a) states that the basal antennal article possesses a large spine at the anterolateral angle—it is in fact midway along and each antenna comprises one short proximal segment followed by a long segment, not two short segments. The carpus and propodus of the palp of the third maxilliped each bear a short spine medially as is typical in species of *Achaeus*—this feature was not mentioned by Griffin & Yaldwyn. Finally, the illustrations of the male first pleopod given by Griffin (1966a: figs 19-3 & 4) are incorrectly designated—fig. 19-3 is of the sternal surface, not the abdominal

and fig. 19-4 is of the abdominal surface; the pleopod curves inwards distally, not outwards.

The present large series agrees with the specimens reported on by Griffin & Yaldwyn (1965) especially as to variation. The number and size of the spines on the supraorbital eave and behind the eave, the form of the cardiac elevation on the carapace and the relative size of the spinules on the ventral surface of the fourth ambulatory dactyls vary widely as previously described. The female has a shorter "neck" than the male.

Takeda (pers. comm.) has pointed out to me that this species was first recorded from Japan (as *A. tenuicollis* Miers) by Terazaki (1902). Terazaki's material came from Misaki, Sagami Bay and Niihima I., Izu, Sagami Sea and his figures agree completely with other descriptions and figures of this species and with available material.

*Achaeus akanensis* Sakai (1938: 224-225, text-fig. 15) was described from a single female from southern Japan. It was said to differ from *A. elongatus* Sakai (= *A. fissifrons* (Haswell)) only in lacking tubercles on the branchial regions except for one anteriorly not far from the midline and in having a very short "neck": this latter feature is characteristic of females of *Achaeus* species as noted by Sakai.

*Achaeus cadelli* Alcock (1895: 71, pl. 5 fig. 1) from the Andamans in the Bay of Bengal appears to differ from *A. fissifrons* in that the rostral lobes are dorsally carinate, the carinae being serrate, the eyestalks are smooth and there do not appear to be any postorbital spinules. Rathbun (1911: 246), describing a damaged specimen from Amirante in the western Indian Ocean, states that the fixed finger of the chela has a large tooth at its proximal third while the dactyl has two or three slightly smaller teeth situated near the palm. The probability that the specimen of "*Achaeus lorina*" recorded by Rathbun (1911) is in fact *A. fissifrons* is discussed by Griffin (1968).

*Distribution*: Eastern Australia from off Noosa Head (Qld) to Bass Strait, western Australia from off North West Cape to just north of Cape Naturaliste; Indo-west Pacific from Iranian Gulf to Japan and New Zealand; 5-80 fms.

#### *Achaeus galathea* n.sp.

Figs 3a, 4, 13a, d.

*Material examined*: A total of 11 specimens as follows:

*Holotype*—Female (ovig.), 4.5 mm, southern Coral Sea, 26°33'S., 153°31'E., dredged, 86 metres, gravel, 5/11/1951, "Galathea" Expedition 1950-52 Sta. 539 (CM).

*Paratypes*—2 males, 8 females (4 ovig.), 3.0-4.5 mm, smallest ovig. ♀ 4.5 mm (legs detached from most specimens), same data as holotype (1 male, 1 female from this series reg. AM P.17516; remaining paratypes CM).

*Description*: Carapace broad, postrostral length barely exceeding carapace width, margins with blunt spines, dorsal surface bearing two long medial spines, regions well defined. Curled hairs grouped medial to orbits, and laterally on hepatic and branchial regions.

Rostral spines short, separated by a V-shaped notch in distal two thirds, bluntly pointed, medial edges weakly sinuous or sometimes with a small tubercle near tip; lateral edges with 3-4 small blunt spinules; dorsal surface of each spine with a weak central ridge.

Supraorbital cave bearing several short, projecting, blunt spinules along outer edge; one or two similar spinules usually present behind cave. Eyestalks long, stout, a broad, flattened, subtriangular process midway along anterior surface and a short stout spine almost level with this ventrally, a prominent tubercle above cornea at distal extremity of eyestalk; cornea large, circular, obliquely subterminal.

Region between cave and swollen hepatic region very short and unconstricted.

Hepatic margin with up to seven blunt spines, largest at widest part, one or two more above and below. Lateral edge of pterygostomian regions with a large tubercle posteriorly, projecting laterally and visible in dorsal view behind hepatic region.

Branchial regions swollen, two blunt spines on margin anteriorly; posterolateral margins bearing closely spaced, blunt spinules, posterior margin with similar, but sharper, spinules.

Dorsal surface of carapace with two very long, slender, apically rounded, upright spines set on broad bases, one far back on mesogastric region and one on cardiac region with a very much shorter but otherwise similar, backwardly-directed spine on its posterior slope. Branchial regions laterally with several low tubercles in

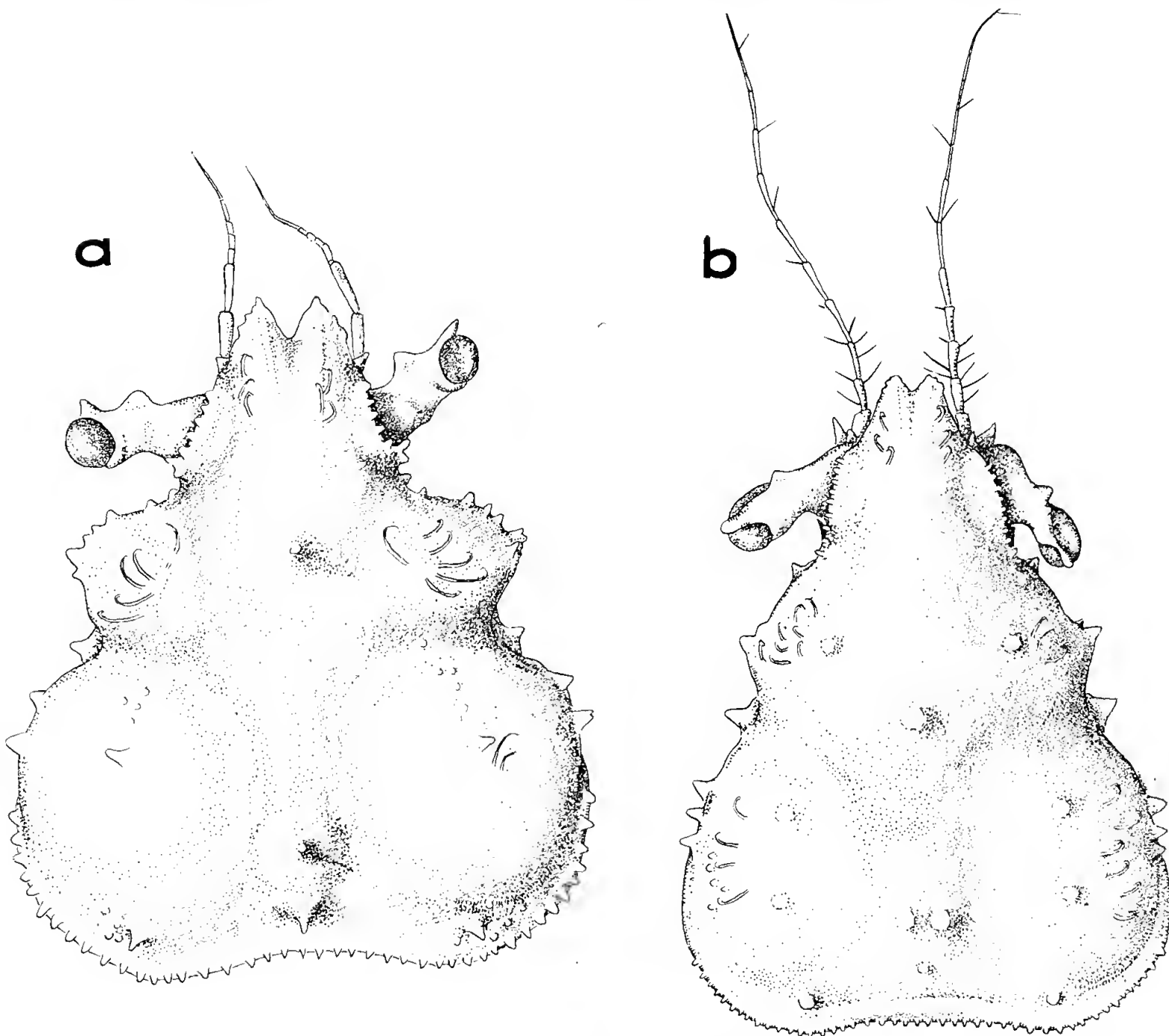


Figure 3.—a, *Achaeus galathea* n. sp., HOLOTYPE, female, carapace, dorsal view; b, *Achaeus paradisei* n.sp., HOLOTYPE, male, carapace, dorsal view.

a group anteriorly in front of one or two small spines; several minute tubercles or spinules posteriorly surrounding a larger spine above base of last ambulatory leg.

Antennular fossae large. Basal segment of antennules bearing two or three short spines near distal edge. Interantennular partition a narrow, triangular compressed lobe.

Basal antennal article narrow, set slightly obliquely, several blunt spinules along lateral edge including a large one midway along; surface with a shallow longitudinal groove centrally.

Epistome wider than long.

Ischium of third maxillipeds with a longitudinal, shallow, central groove and a row of four to six spines along each side; medial edge with numerous small sharp teeth. Merus long, widest

midway along, tapering distally, distal edge truncate; an oblique groove along surface flanked by three or four sharp or blunt spines; anteromedial edge with a few lobes and sharp spines and, about midway along medial edge and just anterior to widest part, a long, medially projecting, stout, apically blunt spine. Palp very long and stout, carpus bearing a few spines around distal edge medially. Medial edge of ischium and all segments of palp bearing long hairs, several around tip of dactyl.

Sternum in both sexes deeply excavated anteriorly, one or two small spines in midline.

Chelipeds in both sexes hardly as long as carapace. Ischium and merus subtrigonal, chelae compressed. Ischium and merus with several spines along dorsal and ventrolateral edges, larger proximally, more numerous ventrolaterally; a few ventromedially. Palm swollen,

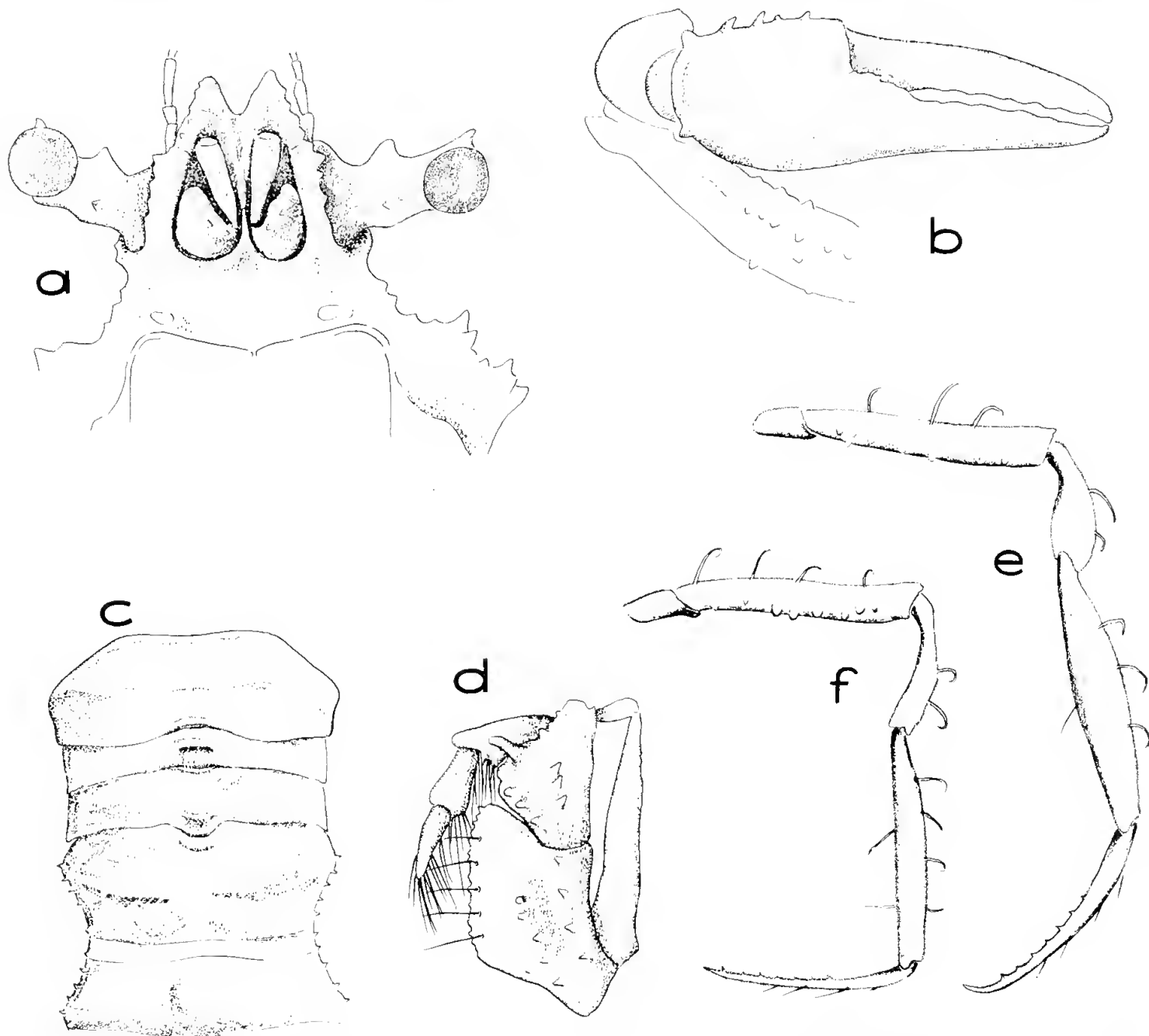


Figure 4.—*Achaeus galathea* n.sp., HOLOTYPE, female (a, d, f) and PARATYPE, male, 3.3 mm, Coral sea, Qld, AM P.17516, (b, c, e). a, front of carapace, ventral view; b, male chela; c, male abdomen; d, left third maxilliped; e, f, right fourth ambulatory leg of male (e) and female (f), posterior aspect.

slightly more than one-third total length of hand, slightly longer than deep; dorsal edge in male and both ventral and dorsal edges in female with about six blunt spines, ventral spines larger than dorsal ones in female. Fingers inwardly curved distally, inner edges closely approximated throughout their length, weakly sinuous but not toothed.

Ambulatory legs no longer than carapace, slender. Propodi noticeably broader in males than in females. First leg the longest; curled hairs sparsely distributed along dorsal surface of meri, carpi and propodi. Meri with blunt spinules or tubercles in an ill-defined ventral row, more numerous and longer in anterior legs. Dactyls of all legs almost straight, ventral edge with a few small denticles along distal two-thirds, larger and more numerous in posterior legs, a large spinule close to tip.

Abdominal segments very broad in both sexes. Male abdomen with third and last segments the longest. Third segment with convex lateral edges, last segment subpentagonal. First three segments bearing small sharp spinules along lateral edges. A curved semi-transverse ridge extending across middle of both third and last segments with a narrow, raised, transverse central area. Female abdomen subcircular, surface covered laterally with scattered blunt spinules which are especially dense on distal part of last segment; free edges of last two segments bearing numerous small sharp spinules. A broad distal central elevation on distal segments bearing a few small spinules.

Male first pleopod short, stout proximally, twisted round completely once and extending distally as an apically blunt process, curved outwards at first and then inwards distally at right angles to proximal portion, aperture along distal edge of groove extending along distal part of abdominal surface; several hairs arising from lateral and swollen sternal surfaces near tip.

*Remarks:* This species is similar to *A. suluensis* (Rathbun, 1916) (see Sakai 1938: 220-222, text fig. 11, pl. 22, fig. 2) except that the ambulatory legs in the male are not quite as broad as Sakai shows, the tubercles on the third abdominal segment in the male are absent, there are four branchial spines which are not present in *A. suluensis*, the rostral spines are spinulate laterally and sometimes medially, not medially as Sakai suggests for *A. suluensis*, and the first pleopods of the male are proximally twisted but not as shown in Sakai's figure.

This series is thus considered to represent a new species allied to *A. suluensis* and *A. superciliaris* (Ortmann) and also to *A. calypso* Forest & Guinot from the eastern Atlantic.

#### *Achaeus lacertosus* Stimpson, 1857

Figs. 1b, 5, 14a, d.

*Achaeus lacertosus*; Buitendijk, 1950: 62. Griffin & Yaldwyn, 1965: 44-46 (lit.). Griffin, 1966a: 38 (in key); 1966b: 276 (in key).

*Material examined:* A total of 28 specimens as follows:

*Australia:* Eight localities from Roebuck Bay, W.A. to Port Jackson, N.S.W. (for further details see Griffin & Yaldwyn, 1965: 44-45), 9 ♂♂,

7 ♀♀ (1 ovig.), 3.7-11.5 mm, ovig. ♀ 8.0 mm. Additional material as follows: *New South Wales*—Watson's Bay, Port Jackson, dredged, 3-5 fms, sand and mud, 8/10/1914, Th. Mortensen, 1 ♂, 7.3 mm (CM); Port Jackson, 18 fms (no other data), 5 ♂♂, 1 ♀, 7.8-10.5 mm (SAM C.1080).

*Japan:* Off Sone, Munakata-oshima Islet, Fukuoka Pref., 3/7/1957, Y. Motomatsu, 3 ♂♂, 2 ♀♀ (1 ovig.), 5.6-7.8 mm, ovig. ♀ 5.9 mm (ZLKU 8679).

*Description:* Carapace broad, length almost 1.3 greatest breadth, margins and dorsal surface generally smooth, without tubercles or spines. branchial and cardiac regions well demarcated by broad grooves from surrounding regions, regions otherwise ill-defined. Curled hairs scattered in groups on hepatic and branchial regions and on each side of midline.

Rostral spines very short, rounded apically, separated by broad V-shaped notch distally, edges bearing numerous prominent spinules.

Supraorbital eave generally unarmed, but sometimes bearing minute spinules along edge. Eyestalks short, stout, without tubercles; cornea large, circular, terminal.

Region behind eave broadening immediately and regularly, unconstricted.

Hepatic regions strongly expanded, margins flattened, rounded, sometimes bearing minute spinules.

Branchial regions swollen, unarmed.

Dorsal surface of carapace smooth, cardiac region tumid. Posterolateral and posterior margins usually with numerous minute spinules in several ill-defined rows.

Antennular fossae large, ovate. Basal segments of antennules smooth. Interantennular partition a narrow compressed triangular lobe.

Basal antennal articles unarmed. Antennae about as long as carapace, first segment smooth.

Epistome much wider than long, a low, broad-based tubercle laterally just outside and forward of opening of green gland.

Ischium of third maxillipeds smooth, a weak longitudinal groove centrally; medial edge minutely toothed. Merus smooth, several spinules along medial edge, distal ones larger; distal edge with a few small spines slightly laterally. Palp long and stout, laterally, medially and apically fringed by long hairs; carpus bearing a small, slender spine medially towards distal edge, propodus with two ventral spines, one long, about midway along and a small one distally. Exopodite smooth.

Thoracic sternum in male smooth.

Chelipeds in male long, robust, hairy. Ischium subtrigonal, merus subtrigonal to subcylindrical and very robust, carpus subcylindrical, chela compressed. Ill-defined ventromedial and ventrolateral edges of merus each with a row of small tubercles; several larger tubercles in a row dorsally. Carpus with several very small spines medially along distal two-thirds, a group of tubercles proximally on dorsolateral surface. Palm moderately robust, about 1½ times as long as high, several short spinules along dorsal edge.

Fingers as long as palm, incurved distally and acute; inner edges weakly gaping proximally, toothed, proximal teeth larger. Chelipeds of female no longer than carapace, slender, merus subtrigonal, tubercles of merus and carpus slightly longer than in male, spinous, palm with spines ventrally as well as dorsally, fingers slightly longer than palm, almost meeting along cutting edges, weakly toothed, teeth larger proximally.

Ambulatory legs long and slender, first the longest, about three times carapace length, remaining legs decreasing regularly in length,

fourth the shortest, about  $1\frac{1}{2}$  times carapace length; curled hairs singly along merus, carpus and propodus dorsally. Dactyls of first two legs long and almost straight, weakly curved distally, unarmed, bearing long straight hairs; dactyls of third and fourth legs semicircular, bearing sharp recurved spines ventrally for distal two-thirds or more, spinules small and sometimes obsolete proximally, largest midway along.

Male abdomen narrow, all segments wider than long, last segment the longest, almost as long as wide. Third segment with strongly

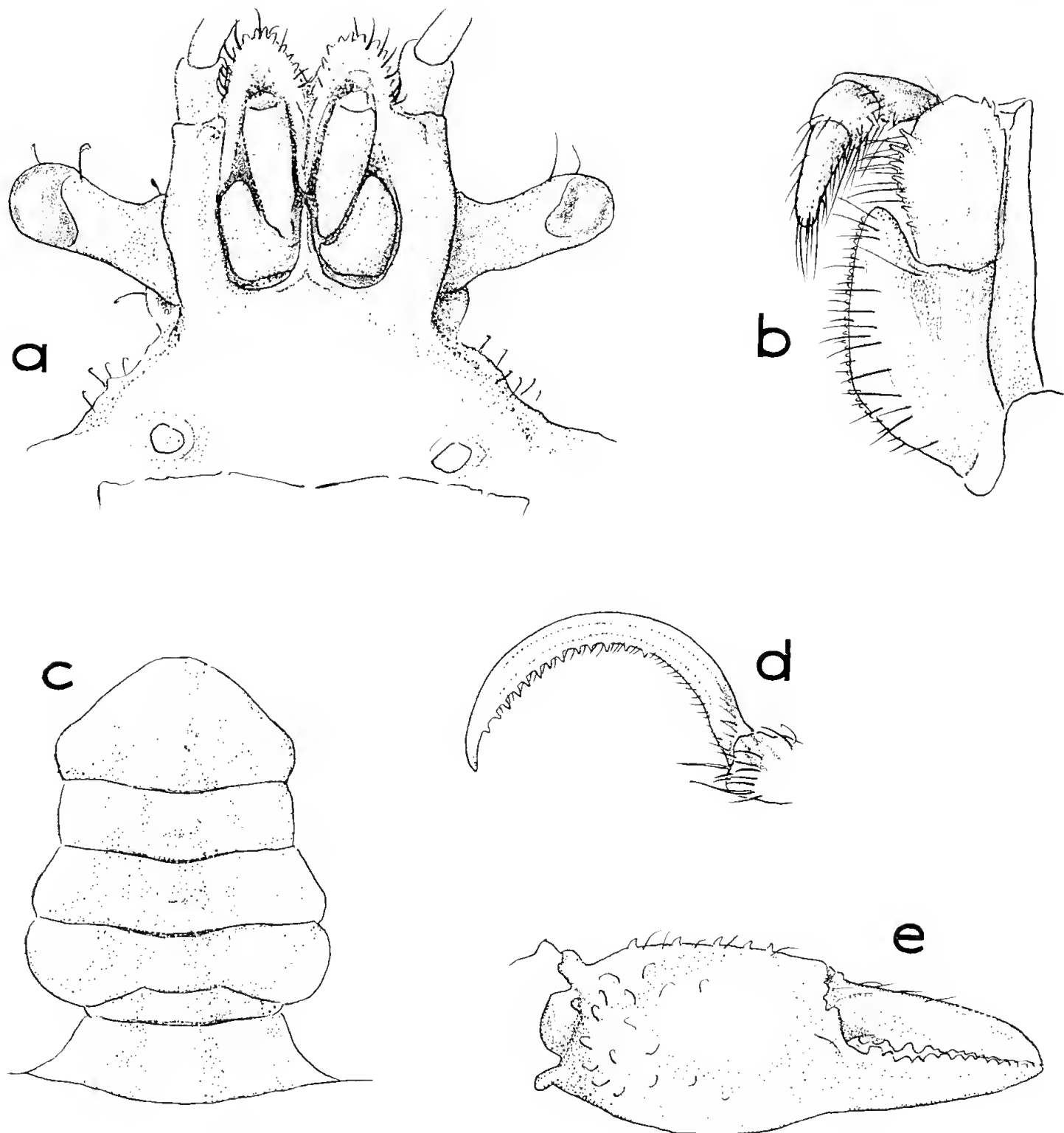


Figure 5.—*Achaeus lacertosus* Stimpson, male, 10.4 mm, Port Stephens, N.S.W. (AM P.162). a, front of carapace, ventral view; b, left third maxilliped; c, abdomen; d, left fourth ambulatory dactyl, posterior view; e, right chela.

convex lateral edges, last segment subtriangular, proximally convex, distally rounded. Surface elevated in midline, bearing a central tubercle on last segment only, otherwise smooth. Female abdomen broad, subovate, elevated in midline.

Male first pleopod moderately slender except for more bulbous base, tip hardly expanded, inwardly curved distally and apically pointed; aperture subterminal, longitudinally subovate, at end of groove extending obliquely across

sternal surface proximally to become lateral in distal half; a fringe of short hairs along distal half of medial surface and a few long plumose hairs at base medially and laterally.

*Measurements:* Male (AM P. 162)—carapace length 10.2 mm, carapace width 8.4 mm, rostrum length 1.2 mm, rostrum width 1.6 mm, cheliped length 15.6 mm, chela length 8.5 mm, chela height 3.1 mm, dactyl length 4.4 mm, first ambulatory leg length 31.5 mm, fourth ambulatory leg length 19.5 mm.

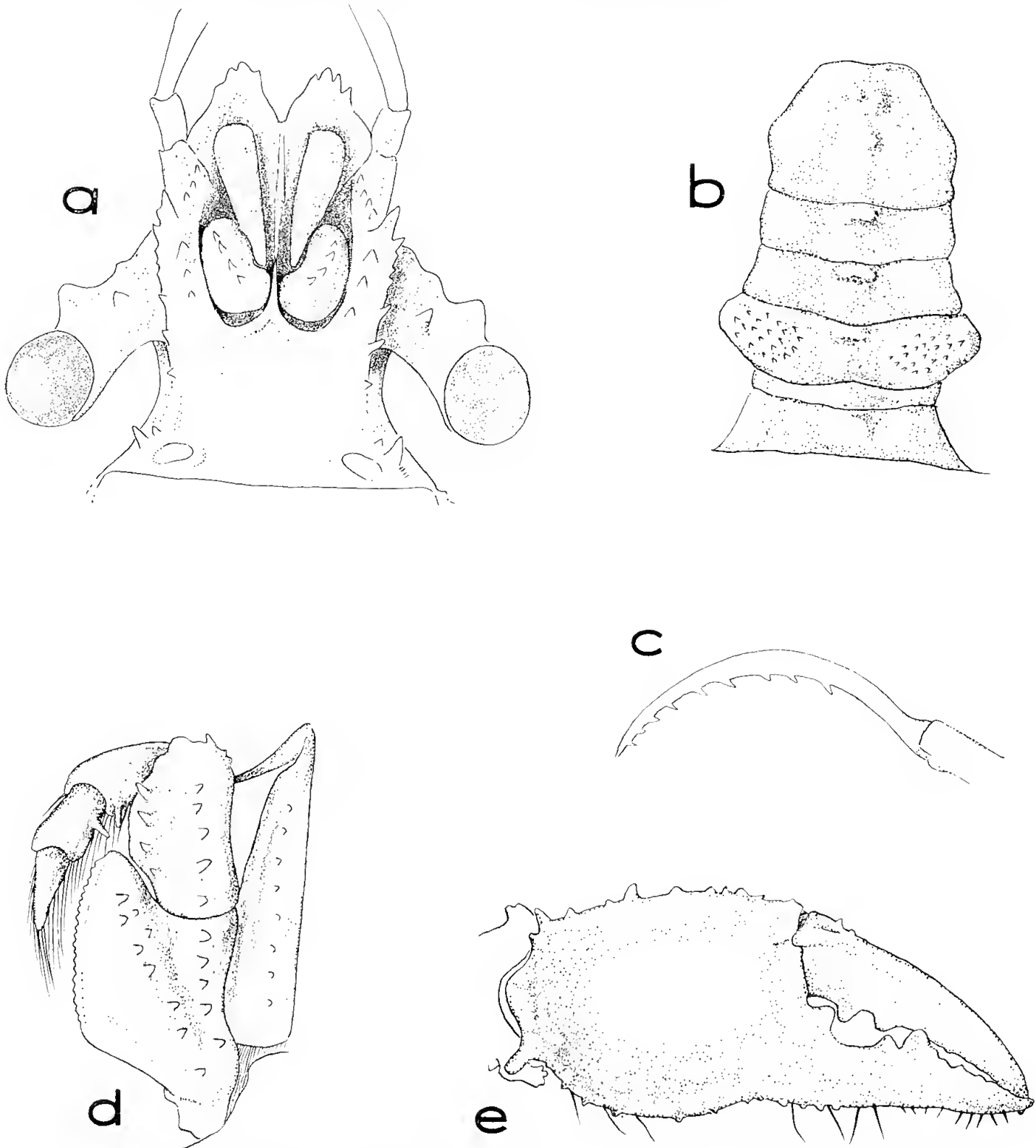


Figure 6.—*Achaeus paradicei* n.sp., HOLOTYPE, male (b, e), PARATYPE, male, 4.2 mm, Coral Sea, Qld (CM) (a, d), PARATYPE, female, 4.5 mm, Coral Sea, Qld (CM) (c). a, front of carapace, ventral view; b, male abdomen; c, left fourth ambulatory dactyl, posterior view; d, left third maxilliped; e, male chela.

Female (AM P. 1700)—carapace length 7.9 mm, cheliped length 9.0 mm, chela length 4.0 mm, chela height 1.0 mm, dactyl length 2.5 mm.

*Remarks:* Re-examination of the series of specimens of this species listed by Griffin & Yaldwyn (1965) confirms that *A. lacertosus* shows considerable variation in spinulation of the supraorbital eave, hepatic margin and posterolateral margins—the presence of spinules was the main feature thought by Sakai to distinguish his *A. spinifrons* from *A. lacertosus*. Five specimens of this species from Japan, kindly sent for examination by Mr. M. Takeda, Kyushu University, show no marked differences from Australian specimens except that the male first pleopod appears slightly stouter and the tip distal to the aperture appears a little shorter. Spinules are well developed along the eave and hepatic margin and around the posterolateral margins of the carapace; the ischium of the third maxilliped bears some very low tubercles in two oblique rows. That Sakai's species is conspecific with Stimpson's is therefore confirmed.

More detailed comparison of the male first pleopod of the present material with the figure given by Stephenson (1945: fig. 18c) (see Griffin & Yaldwyn 1965: 45) shows that there is good agreement and Iranian Gulf material is considered to be conspecific with Australian.

The characteristic features of *A. lacertosus* are the smooth carapace and the spinulate rostrum bearing curled hairs.

*Distribution:* Western, northern and eastern Australia from Broome (WA) to Port Jackson (NSW); Indo-west Pacific from South Africa to Japan; 3-45 fms. Buitendijk (1950) recorded the species from Pawai Island near Singapore.

***Achaeus paradisei* n.sp.**

Figs. 3b, 6, 15b, c.

*Achaeus* sp. Griffin & Yaldwyn, 1965: 33. Griffin, 1966a: 38; 1966b: 276.

*Material examined:* A total of 10 specimens as follows:

*Holotype*—Male, 5.4 mm, southern Coral Sea, 26°33'S., 153°31'E., dredged, 86 metres, gravel, 5/11/1951, "Galathea" Expedition 1950-52 Sta. 539 (CM).

*Paratypes*—Two males, six female (5 ovig.), 4.0-5.0 mm, smallest ovig. ♀ 4.5 mm (many with legs detached), same data as for holotype (1 male, 1 female now reg. AM P.17517; remaining paratypes from this series CM).

One female (ovig.), 4.5 mm, Gibson Reef, off Cairns, Queensland, 28 fms, before 1925, W. E. J. Paradise (AM P.7985—specimen in spirit, some legs detached but in same tube as rest of animal).

*Description:* Carapace moderately elongate, length almost 1½ times greatest breadth, margins with a few stout, blunt spines or tubercles, dorsal surface with 11-12 blunt tubercles, otherwise smooth. Branchial and cardiac regions well demarcated by broad groove from surrounding regions, regions otherwise ill-defined. Curled hairs grouped along base of rostral spines and laterally on hepatic and branchial regions.

Rostral spines very short, separated by broad V-shaped notch in distal third, rounded apically, up to four blunt spinules on margins, most apical the largest and sharpest.

Supraorbital eave bearing along outer edge, at least posteriorly, many minute blunt spinules; some spinules immediately behind eave. A short, slender, curved spine at posterolateral corners of epistome partly visible in dorsal view behind eave. Eystalks long and stout, a prominent flattened triangular process midway along anterior edge, a small blunt tubercle opposite on ventral surface and a prominent tubercle above cornea at distal extremity of eystalk; cornea large, circular, obliquely sub-terminal.

Region between eave and hepatic region broadening regularly, unconstricted.

Hepatic regions weakly inflated, laterally acute, with a group of two to four broad, stout spines. Pterygostomian regions with a large tubercle posterolaterally and visible in dorsal view behind hepatic region.

Branchial regions, swollen, three or four acute spines just forward of widest part of carapace on margin, first two larger than others and a few small tubercles sometimes behind these. Posterolateral and posterior margins bordered by minute, sharp spinules.

Dorsal surface of carapace with a low, broad-based, conical spine far back on mesogastric region, tumid cardiac region with two blunt tubercles side by side and a small medial intestinal tubercle sometimes on posterior slope. Two large tubercles on protogastric regions laterally forward of mesogastric spine. Six similar tubercles laterally on branchial regions, three on each side in a semi-circle, one anteriorly, one opposite cardiac tubercle, and one near posterior margin above base of last ambulatory leg.

Antennular fossae large, anterolaterally somewhat outwardly splayed. Basal segment of each antennule bearing three or four small, sharp spinules near distal edge. Interantennular partition a narrow compressed triangular lobe.

Basal antennal articles terminating in a large, sharp spine directed anteriorly, lateral edge bearing six to eight small, sharp spines, three more spines along medial edge. Antennae as long as carapace, first segment with three or four spinules ventrally.

Epistome slightly longer than wide, a spine laterally just outside and forward of opening of green gland with a smaller spine sometimes immediately in front of it.

Ischium of third maxillipeds with two distally divergent, oblique, ill-defined rows of spines on each side of a shallow longitudinal groove; medial edge minutely toothed. Merus with two subparallel, longitudinal rows of spines on each side of shallow groove which extends 2/3 of length towards distal edge; distal edge irregularly crenulate and lobed, a few small spines slightly laterally. Palp long and stout, laterally, medially and apically fringed by long hairs; carpus bearing a strong, slender spine medially towards distal edge, propodus with a similar ventral spine about midway along its length.

Exopodite bearing a longitudinal row of small tubercles along its outer surface.

Thoracic sternum in male densely covered by small tubercles.

Chelipeds in male long, about  $1\frac{1}{2}$  times carapace length, granular and densely tuberculate, chelae robust. Ischium subtrigonal, merus subtrigonal to subcylindrical, carpus subcylindrical, chela compressed. Ill-defined ventromedial and ventrolateral edges of merus with rows of irregularly sized blunt and sharp spines. Carpus with several small spines medially and laterally and a group of about 4 larger tubercles proximally on dorsal surface. Distal articulating processes dorsally and ventrally spinulate. Chela with palm little longer than high, bearing dorsally and ventrally irregularly sized spinules or tubercles which are larger dorsally; spinules extending along proximal part of fingers dorsally and ventrally. Fingers as long as palm, incurved distally and acute; inner edges toothed; fixed finger with a large tooth at base and two more teeth, the first the smaller and sometimes obsolete, close together midway along and separated from basal tooth by a broad hiatus; dactyl with two large teeth not far from base and fitting into hiatus between basal and remaining teeth of fixed finger; distal parts of both fingers with irregular small teeth along inner edges which meet apically. Ventromedial edge of merus, medial surface of carpus and ventral edge of chela with large and small straight hairs. Cheliped of female no longer than carapace, slender, merus subtrigonal; spines of merus, carpus and propodus much longer than in male, in particular a comb-like row of long spines along ventrolateral edge of merus; fingers as long as palm, almost meeting along cutting edges, weakly toothed, teeth larger and closer together distally.

Ambulatory legs very long and slender, first the longest, about  $3\frac{1}{2}$  times carapace length, remaining legs decreasing regularly in length, fourth the shortest, about twice carapace length; curled hairs singly along carpus and propodus dorsally. Dactyls of first two legs long and almost straight, weakly curved distally only and unarmed, bearing long straight hairs; dactyls of third and fourth legs falcate, bearing sharp, recurved spines ventrally for almost entire length, spinules very small or occasionally obsolete in proximal half, larger in distal half except last one or two which are slightly smaller.

Male abdomen with all segments, except last, wider than long, last segment the longest, as long as wide. Third segment, with strongly convex lateral edges, last segment subpentagonal distally subtruncate. Surface elevated in midline, bearing a tubercle on first segment, a wide elevation distally on third to fifth segments and on the last a central tubercle and a transverse pair of smaller tubercles not far from distal edge; third segment laterally inflated with spinate surface. Female abdomen broad, elongate subovate, elevated in midline.

Male first pleopod moderately slender except for more bulbous base, tip expanded, curved medially and subtruncate; aperture subterminal, a distal slit at end of groove extending along lateral surface for distal half; a fringe of short hairs distally along medial surface, a few short

hairs midway along medial surface, and a few long plumose hairs at base medially and laterally.

*Measurements:* Male (holotype)—carapace length 5.4 mm, carapace width 3.8 mm, rostrum length 0.8 mm, rostrum width 0.8 mm, cheliped length 6.2 mm, chela length 3.5 mm, chela height 1.3 mm, dactyl length 2.0 mm.

Female (paratype)—carapace length 5.0 mm, cheliped length 6.5 mm, chela length 2.9 mm, chela height 0.8 mm.

Female (paratype)—carapace length 4.8 mm, first ambulatory leg length 15.5 mm.

*Remarks:* In general shape and ornamentation of the carapace and arrangement of teeth on the chela in the males, *A. paradisei* closely resembles *A. brevirostris*. However, there are a number of important differences. *A. paradisei* is a much smaller species, reaching maturity (as judged by expansion of male chelae and female abdomen) at a carapace length of 4.5 mm (6.8 mm minimum in *A. brevirostris*), the males have a much shorter and less constricted postorbital 'neck', the rostral lobes are separated by a V-shaped notch (usually U-shaped in *A. brevirostris*) and are apically armed with spinules (absent in *A. brevirostris*), the edges of the supraorbital caves bear numerous spinules (absent in *A. brevirostris*), the exopodite of the third maxilliped bears a row of spinules (smooth in *A. brevirostris*), there is a spine and a tubercle on the epistome close to the opening of the green gland (a single small tubercle in *A. brevirostris*), there are three or four prominent tubercles in a row immediately below the branchial margin anteriorly (two low tubercles in *A. brevirostris*), the posterolateral and posterior margins are spinulate (smooth in *A. brevirostris*), the fourth ambulatory dactyls are ventrally spinulate for only the distal  $\frac{2}{3}$  (for entire length in *A. brevirostris*), the third segment of the abdomen in the male bears numerous spinules (smooth in *A. brevirostris*) and the merus of the cheliped of the female bears a comb-like row of long spines ventrolaterally (about four short spines concealed by long hairs in *A. brevirostris*). In addition, *A. paradisei* is a less hairy species and the tufts of curled hairs around the rostral lobes so characteristic of *A. brevirostris* are absent in this new species and the carapace tubercles are more prominent.

The new species is named for Dr W. E. J. Paradise who collected the specimen from Gibson Reef which originally indicated (Griffin & Yaldwyn, 1965) that this previously undescribed species existed in Australia.

*Distribution:* Eastern Australia from off Cairns to off Noosa Head (Qld), 28-44 fms.

#### *Achaeus podocheloides* n.sp.

Figs 7a, 8, 14e, f.

*Material examined:* A total of four specimens as follows:

*Holotype*—Male, 8.1 mm, N.W. of Jurien Bay, Western Australia, 30°00'S., 114°22'E., 70-75 fms, 28/1/1964, HMAS "Diamantina" Cruise 1/64, CSIRO Sta. 3 (WAM 95-67).

*Paratypes*—1 female, 6.5 mm, S.W. of Point Cloates, W.A., 23°39'S., 113°11'E., 73 fms, 7/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 187 (WAM 331-67).

1 female, 4.8 mm, N.W. of Carnarvon, W.A., 24°59'S., 112°27'E., trawled, 71 fms, 8/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 197 (AM P.16779—ex WAM 276-67 part).

1 male, 7.8 mm, N.W. of C. Naturaliste, W.A., 33°40'S., 114°28'E., 75 fms, 27-28/7/1963, HMAS "Diamantina" Cruise 4/63, CSIRO Sta. 134 (AM P.16774—ex WAM 332-67).

*Description*: Carapace elongate, length slightly more than  $1\frac{1}{2}$  greatest breadth, lateral margins with a few sharp spines and spinules, dorsal

surface with 11 blunt tubercles. Branchial and cardiac regions well demarcated by broad grooves from surrounding regions, other regions ill-defined. Curled hairs scattered over lateral parts of carapace.

Rostral spines short, separated by very broad V-shaped notch in distal third, each terminating in a small weakly upturned spine.

Supraorbital eave unarmed. Eyestalks long and stout, two spinules about midway along anterior edge, more distal the larger, proximal one somewhat ventral, a prominent tubercle above cornea at distal extremity of eyestalk; cornea large, circular, obliquely subterminal.

Region between eave and hepatic region broadening regularly, weakly constricted, two to four spinules not far behind eave.

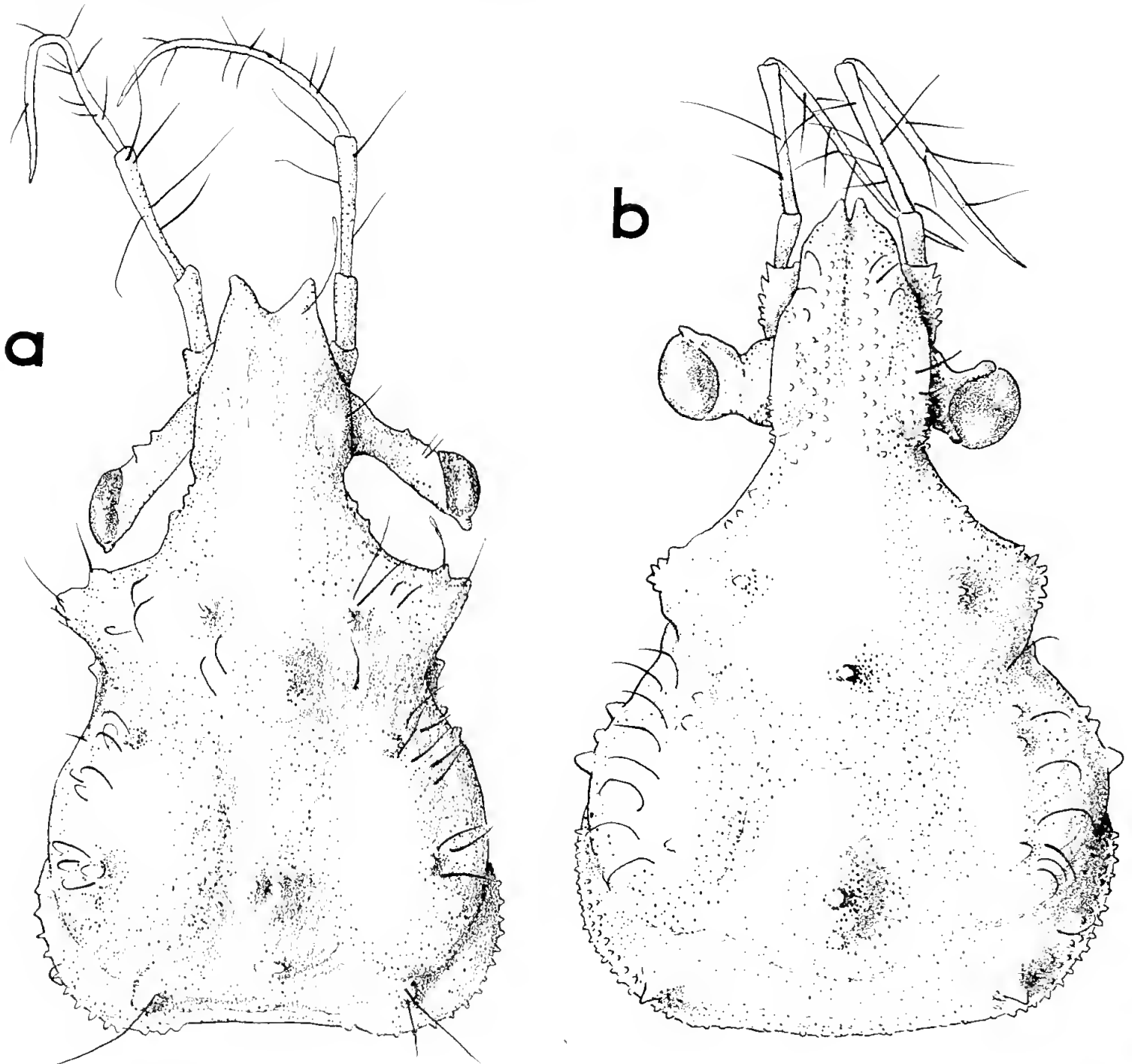


Figure 7.—a, *Achaeus podocheioides*, n.sp., HOLOTYPE, male, carapace, dorsal view; b, *Achaeus pugnax* (De Man), male, 5.5 mm, S.W. of Pt. Cloates, W.A. (WAM 125-67), carapace, dorsal view.

Hepatic regions inflated, laterally acute, with a group of two to four stout spines and spinules. Pterygostomian regions with a small tubercle posterolaterally and visible in dorsal view behind hepatic region.

Branchial regions swollen, margins with a small spine anteriorly; posterolateral margins bordered by spinules.

Dorsal surface of carapace with a low, broad-based, conical tubercle far back on mesogastric region, cardiac region with two blunt tubercles submedially surmounting prominent elevation and a very obscure medial tubercle on posterior slope. Two blunt tubercles submedially on protogastric region forward of mesogastric tubercle; three tubercles laterally on branchial regions in a curved row, first anteriorly, second opposite cardiac elevation, third tubercle near posterior margin above base of each ambulatory leg.

Antennular fossae large. Basal segment of each antennule bearing four or five spinules near base. Interantennular partition narrow.

Basal antennal articles with two or three spinules distally. Antennae almost as long as carapace, first segment with two or three spinules distally.

Epistome slightly longer than wide.

Ischium of third maxillipeds with two or three sharp spines on lateral side of a shallow longitudinal groove and up to five similar spines medially; medial edge minutely toothed. Surface of merus unarmed, two to four spines on medial edge, distal edge with a few small spines slightly laterally. Palp long and stout, laterally, medially and apically fringed by long hairs; carpus bearing a strong, slender spine medially towards distal edge, propodus with a similar spine distally. Exopodite smooth.

Thoracic sternum in male with a few small tubercles laterally and several around anterior edge of abdominal fossa.

Chelipeds in male long, chelae moderately robust. Ischium subtrigonal, merus subtrigonal to subcylindrical, chela compressed. Ill-defined

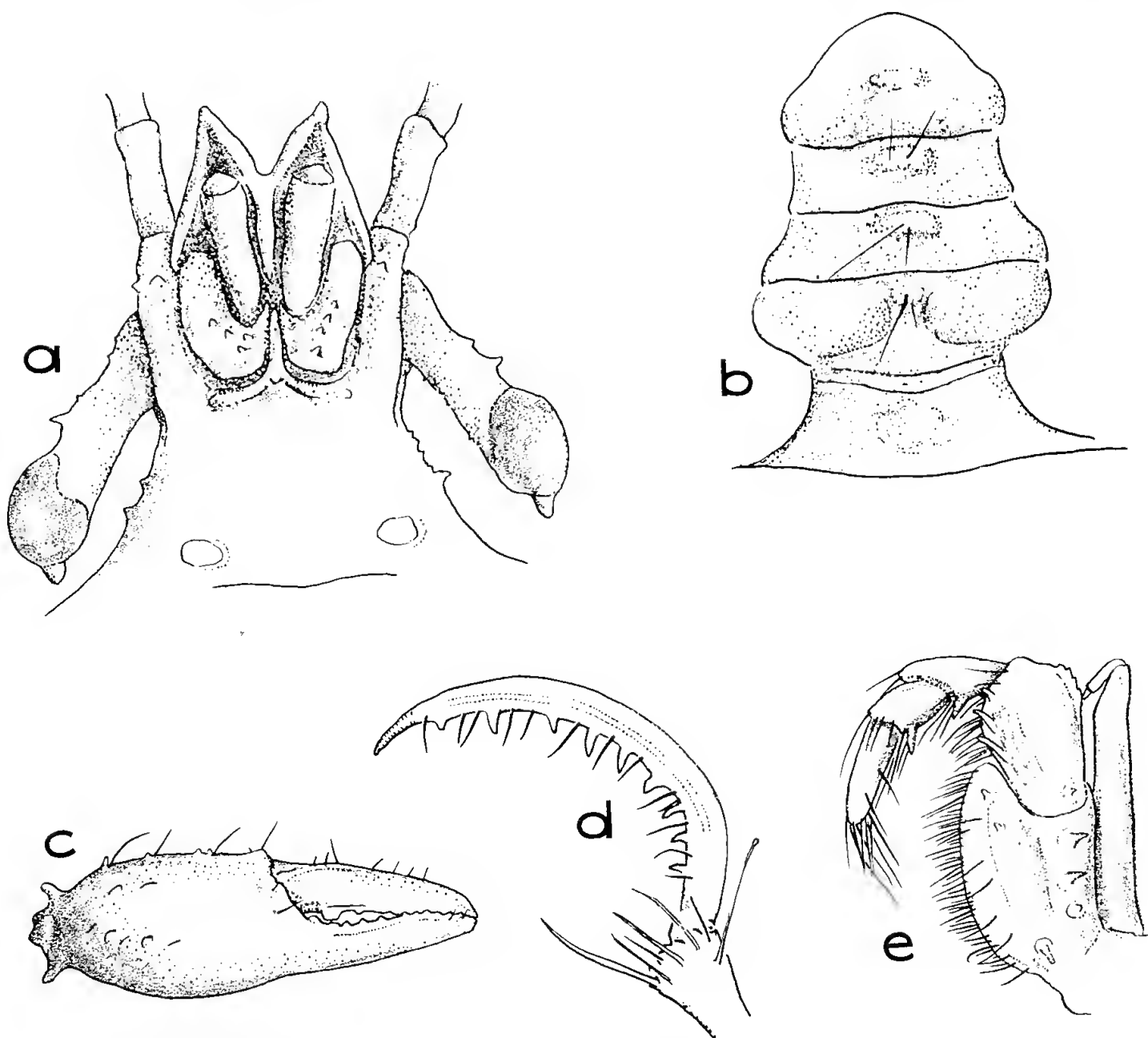


Figure 8.—*Achaeus podocheloides* n.sp., HOLOTYPE, male. a, front of carapace, ventral view; b, abdomen; c, right chela; d, left fourth ambulatory dactyl, posterior view; e, left third maxilliped.

ventromedial and ventrolateral edges of merus with a few blunt and sharp spines proximally and distally on ventrolateral edge and proximally on ventromedial edge; three slightly longer spines equally spaced along dorsal surface. Carpus with several small spines laterally, some denticles medially and a group of about four larger tubercles proximally on dorsal surface. Chela with palm twice as long as high, bearing three or four irregularly sized spinules dorsally. Fingers as long as palm, incurved distally and acute; inner edges adjacent, coarsely toothed; dactyl with a large tooth near base. Ventromedial edge of merus, dorsomedial surface of carpus and ventral edge of chela with large and small straight hairs. Chelipeds of female no longer than carapace, extremely slender, weakly spinous, ventrally and dorsally hairy, chela of uniform width throughout, fingers as long as palm, meeting along weakly toothed cutting edges.

Ambulatory legs very long and slender, first the longest, almost four times carapace length, remaining legs decreasing regularly in length, fourth the shortest, almost three times carapace length; long straight hairs and curled hairs singly along merus, carpus and propodus dorsally. Dactyls of first two legs long and almost straight, weakly curved distally and unarmed, bearing long straight hairs; dactyls of third and fourth legs falcate, bearing sharp recurved spines ventrally for almost entire length.

Male abdomen with all segments wider than long, last the longest, almost as long as wide. Third segment with strongly convex lateral edges, last segment subtriangular, distally rounded. Surface elevated in midline, bearing a short spine on first segment, a wide elevation distally on third to fifth segments and on the last a central tubercle; third segment laterally inflated, smooth. Female abdomen broad, elongate subovate, elevated in midline.

Male first pleopod bulbous basally, more slender midway along, weakly expanded in distal half and weakly curved, tip blunt; aperture subterminal, a long slit on medial surface at end of groove extending along medial surface and partly covered by a transparent projection on sternal surface; a few long plumose hairs at base laterally, surface otherwise naked.

**Measurements:** Male (holotype)—carapace length 7.9 mm, carapace width 4.6 mm, rostrum length 1.0 mm, rostrum width 1.2 mm, cheliped length 12.3 mm, chela length 5.6 mm, chela height 1.9 mm, dactyl length 3.3 mm, first ambulatory leg length 32.0 mm, fourth ambulatory leg length 24.5 mm.

Female (paratype)—carapace length 6.5 mm, cheliped length 8.0 mm, chela length 4.4 mm, chela height 0.9 mm, dactyl length 2.2 mm.

**Remarks:** This species resembles *A. brevifalcatus* in several features including pointed rostral spines, cardiac region surmounted by a pair of tubercles, postorbital region with spinules, posterolateral border of carapace with spinules, eyestalk with two small tubercles or spines, merus of third maxillipeds with spines along medial edge, dactyls of last ambulatory legs

falcate and ventrally spinulate for more than half their length and abdomen of the male with a single tubercle on the last segment.

However, the two species differ markedly in several features, the most important of which is the form of the male first pleopod. In *A. brevifalcatus* the general shape and position of the aperture is much the same as in the majority of *Achaeus* species. In *A. podoche-loides*, on the other hand, the aperture is subterminal and partly surrounded by a flap of tissue; such a pleopod is typical of American inachines such as *Podocheila* species (where the flap is greatly developed). Other differences between *A. brevifalcatus* and *A. podoche-loides* are the presence of spinules on the supraorbital eave in *A. brevifalcatus* but not in *A. podoche-loides*, the more pronounced development of spinules behind the eave in the former, the presence of protogastric and branchial tubercles in *A. podoche-loides*, the paucity of spinules on the basal antennal article and the absence of spinules close to the posterolateral margin of the carapace in *A. podoche-loides* whereas *A. brevifalcatus* has numerous spinules on the basal antennal article and on the posterolateral regions of the carapace near the border in addition to those on the border. Finally, in *A. brevifalcatus* the lateral margins of the third segment of the male abdomen are spinate proximally (smooth in *A. podoche-loides*) and the fingers of the chela in the male gape widely in the proximal  $\frac{1}{2}$  to  $\frac{2}{3}$  and two prominent teeth project into the gape (in *A. podoche-loides* the fingers gape only slightly).

*A. podoche-loides* is similar to a new species described elsewhere by M. Takeda (pers. comm.) from a single male taken in 200 metres at Ogasawara I., Japan. The resemblances are particularly noticeable in carapace shape and ornamentation and in the form of the first pleopod of the male. However, the Japanese species differs in having more acuminate rostral spines, a strong spine on each eyestalk, spinules on the supraorbital eave anteriorly, more spines on the third maxilliped, a longitudinal elevation on the outer surface of the palm of the chela and the terminal segment of the abdomen in the male is sharp. There are possibly other more minor differences also.

**Distribution:** Western Australia from off Point Cloates to just north of Cape Naturaliste, 70-75 fms.

#### *Achaeus brevifalcatus* Rathbun, 1906

Figs 9, 10, 14b, c.

*Achaeus affinis*; Rathbun, 1906:877, Not *Achaeus affinis* Miers, 1884 (—*A. brevirostris* (Haswell)).

*Achaeus brevifalcatus* Rathbun, 1911: 244-246, fig. 2.

**Material examined:** At the time of the description of this species Rathbun had available a male and a female taken by the "Sealark" and the material from Hawaii, which she considered to be conspecific with the "Sealark" specimens, reported upon previously (Rathbun, 1906) as *Achaeus affinis*. No statement was made as to which was the holotype. I choose as LECTOTYPE the male, c.l. 6.6 mm (USNM 41380).

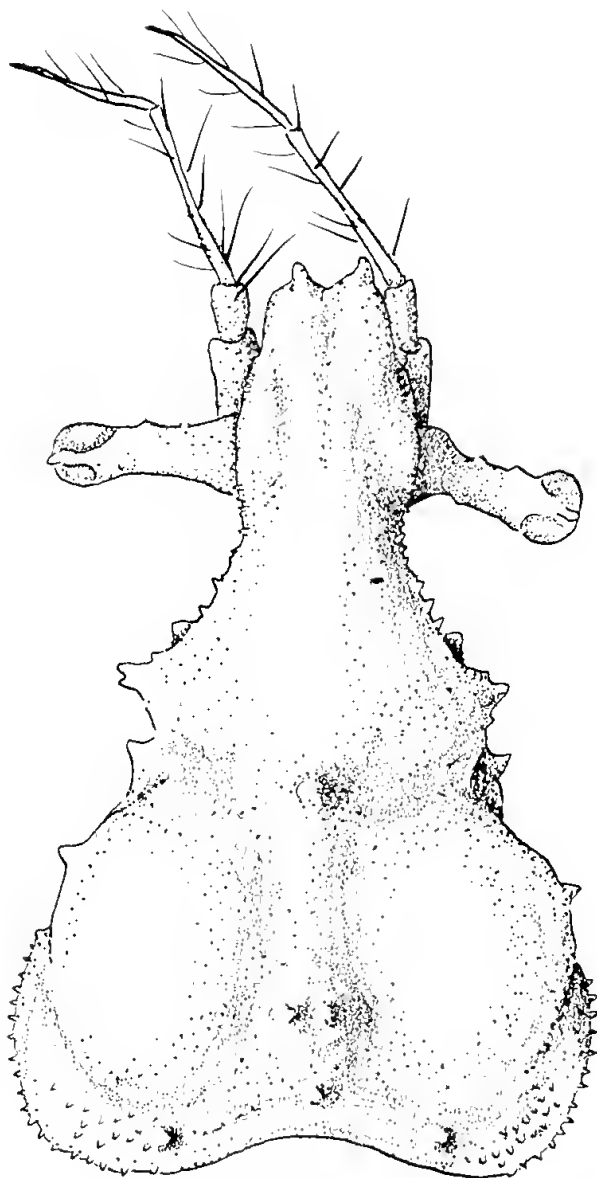


Figure 9.—*Achaeus brevifalcatus* Rathbun, LECTO-TYPE, male, carapace dorsal view.

taken by the "Sealark" from the Seychelles and figured by her; details are as follows: Seychelles, western Indian Ocean, 44 fms, H.M.S. "Sealark", 20/10/1905, Percy Sladen Trust Expedition Sta. F5. The female (USNM 41397) from Sta. F4, Seychelles, 39 fms, 20/10/1905 is designated PARALECTOTYPE.

The Hawaiian specimens have also been re-examined; details are as follows: Hawaiian Islands (for full details see Rathbun, 1906), 50-163 fms, 1902. U.S. Fisheries Commission Steamer "Albatross" Sta's 3845, 3939, 4063, 4072, 2 ♂♂, 4 ♀♀ (3 ovig.), 3.5-7.3 mm, smallest ovig. ♀ 5.4 mm (USNM 29741-5; 1 ♂ from Sta. 4063 sent to Stanford University, 1908).

**Remarks:** Rathbun's (1911) description is accurate in all details. However, re-examination of the male from the type series allows the following details to be added. The supraorbital cave bears numerous minute denticles in a group anteriorly and posteriorly, the latter merging into a group of larger spinules which extend along the postorbital region laterally to almost merge with the hepatic spinules. The basal article of the antennules bears about five

spinules. The third maxillipeds bear several small spines in two longitudinal rows on both the ischium and merus, the medial row on the merus lying near the edge distally; the anterolateral border of the merus also bears three spines and the carpus and propodus each bear a medial spine. The merus of the cheliped is subtriangular and the ventral surface bears a row of blunt spinules whilst there are several similar spinules scattered over the medial surface. The dactyl of the fourth ambulatory leg is almost semi-circular and ventrally spinulate for slightly more than the distal two-thirds. The third segment of the abdomen bears spinules along the lateral edge proximally; the last segment bears a central tubercle as noted by Rathbun. The posterior sternites bear numerous spinules and there are two small spines submedially transversely on that opposite the chelipeds just in front of the abdominal fossa; the lateral margins of all sternites are minutely spinulate. Finally, the first pleopod of the male in this species is weakly curved and apically flattened, expanded and subtruncate, the opening is at the tip of the sternal surface and there are a few plumose hairs on the lateral surface near the base and also close to the tip.

Hawaiian material (Rathbun 1906, as *Achaeus affinis*) agrees very closely with the lectotype from the Seychelles; the details of the chelae and first pleopod in the males are the same. In the Hawaiian specimens the gastric tubercle is small or obsolete and the spinules on the eave and posterolateral margins are small or absent; the third segment of the male abdomen bears spinules on the proximal parts of the lateral surfaces. The carapace in the females is less constricted behind the orbits than in males as is usual.

**Distribution:** Western Indian Ocean at the Seychelles; central Pacific Ocean at Hawaii; 44-169 fms.

#### *Achaeus pugnax* (De Man, 1928)

Figs 7b, 11, 15a, d.

*Achaeopsis pugnax* De Man, 1928: 7-14, figs 1a-i.

*Achaeus pugnax*: Sakai, 1938: 222-223, text-fig.

12, pl. xxiii fig. 2 (lit); 1965: 68, pl. 28 fig. 2.

*Achaeus stenorhynchus* Rathbun, 1932: 29.

**Material examined:** A total of 12 specimens as follows:

**Western Australia**—S.W. of Point Cloates, 23°39'S., 113°11'E., beam trawl, 73 fms, 7/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 187, 1 ♂, 3 ♀♀ (2 ovig.), 5.1-5.5 mm, smaller ovig. ♀, 5.2 mm (WAM 125-67; 1 ♀ now reg. as AM P.16773); 1 ♀ (ovig.), 5.4 mm (WAM 336-67-part). N.W. of Carnarvon, 24°04'S., 112°53'E., beam trawl, 75½ fms, 8/10/1963, HMAS "Diamantina", Cruise 6/63, CSIRO Sta. 192, 3 ♂♂, 2 ♀♀ (ovig.), 5.3-5.6 mm, smaller ovig. ♀ 5.3 mm (WAM 167-67; 1 ♂ now reg. as AM P.16772). N.W. of Dirk Hartog I., 25°31'S., 112°29'E., 71 fms, 9/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 200, 2 ♀♀, 5.6, 5.7 mm (WAM 67-67).

**Description:** Carapace moderately elongate, length almost 1½ greatest breadth, margins with some spinules and a few stout tubercles, dorsal

surface with 10-11 blunt tubercles and two stout spines. Branchial and cardiac regions well demarcated by broad grooves from surrounding regions, regions otherwise ill-defined. Curled hairs scattered singly and in groups along each side of midline anteriorly and laterally on hepatic and branchial regions.

Rostral spines very short, close together, separated by a very narrow V-shaped notch in distal fifth, subacute apically, sometimes with a few spinules on lateral margins.

Supraorbital eave bearing numerous spinules on surface and along outer edge, spinules sometimes obscure except along posterior part of outer edge; several similar spinules behind eave laterally. Eyestalk short and very stout, a small tubercle above cornea at distal extremity of eyestalk; cornea large, circular, obliquely sub-terminal.

Region between eave and hepatic region broadening regularly, unconstricted.

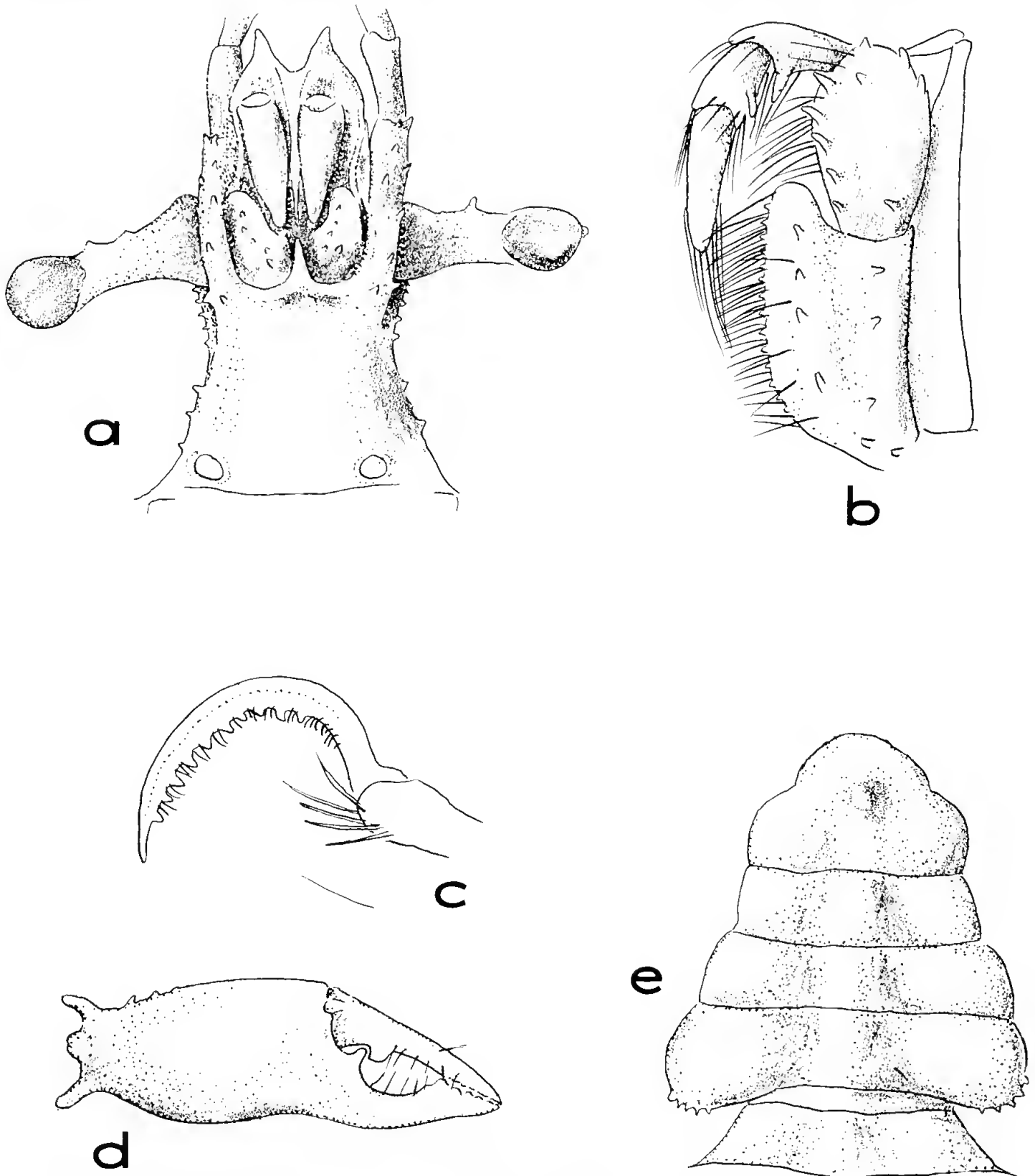


Figure 10.—*Achaeus brevifalcatus* Rathbun, LECTOTYPE, male. a. front of carapace, ventral view; b. left third maxilliped; c. right fourth ambulatory dactyl, anterior view; d. right chela; e. abdomen.

Hepatic regions weakly inflated, laterally rounded, a group of several spinules laterally and on margin.

Branchial regions swollen, three or four blunt tubercles just forward of widest part of carapace. Posterolateral margins bordered by minute, sharp spinules in several ill-defined rows, posterior margin with smaller and less numerous spinules.

Dorsal surface of carapace with numerous very small tubercles anteriorly along each side of medial groove which extends from rostrum to

opposite posterior edge of supraorbital eave; a tall, stout, broad-based, blunt spine far back on mesogastric region sometimes weakly curved posteriorly and bearing minute spinules on anterior surface and at tip; a similar but basally much stouter tubercle centrally on tumid cardiac region, sides and tip of spine with minute spinules, a small medial intestinal tubercle sometimes on posterior slope. Two small tubercles or groups of spinules on protogastric regions laterally anterior to mesogastric tubercle, several smaller tubercles laterally on branchial regions

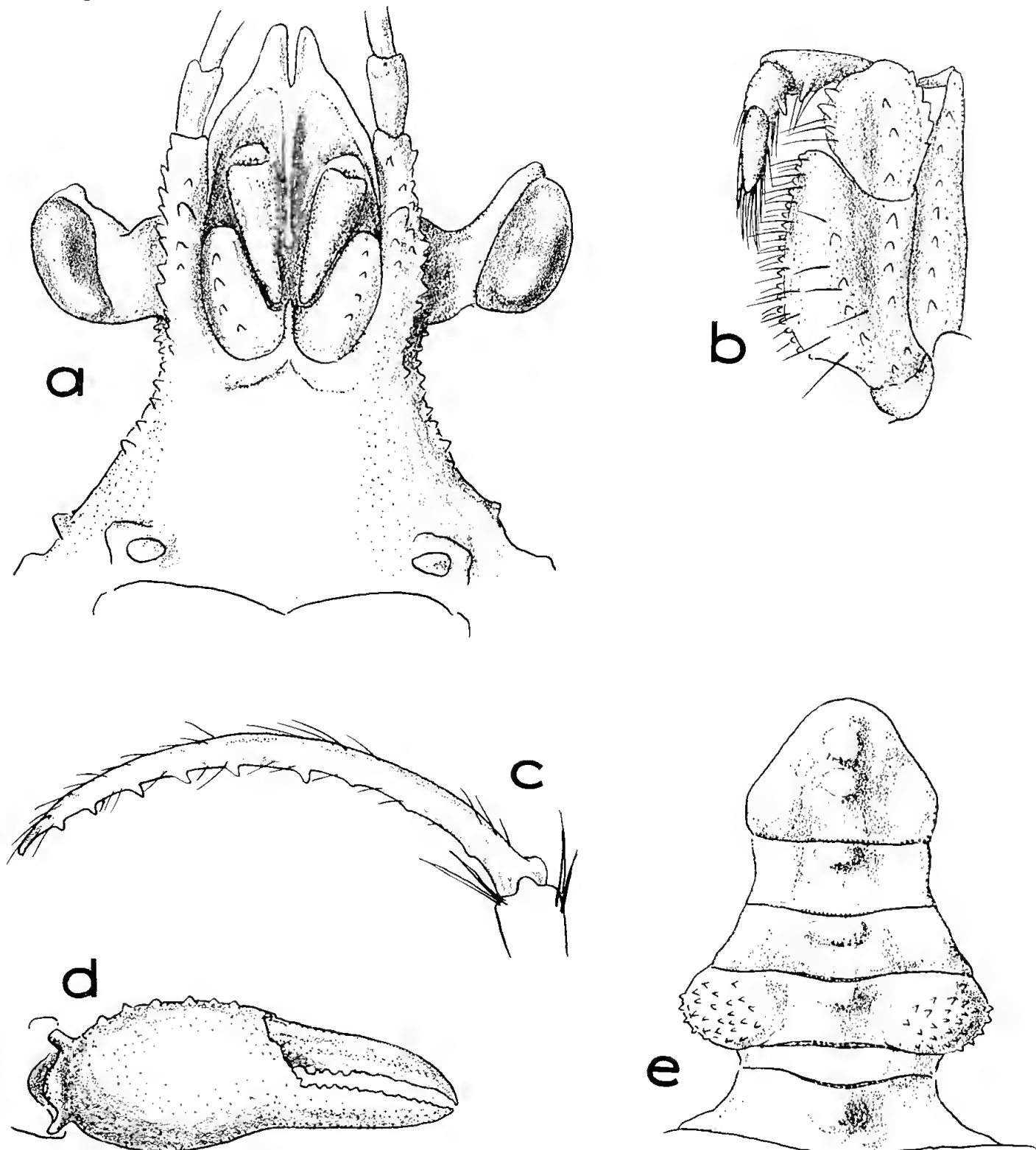


Figure 11.—*Achaeus pugnax* (De Man), male, 5.5 mm, S.W. of Point Cloates, W.A. (WAM 125-67). a, front of carapace, ventral view; b, left third maxilliped; c, left fourth ambulatory dactyl, posterior view; d, right chela; e, abdomen.

in front of cardiac tubercle, a prominent sharp spine or elevated group of spinules near posterior margin above base of last ambulatory leg.

Antennular fossae large, subovate. Basal segment of each antennule bearing several small sharp spinules. Interantennular partition a narrow, compressed, triangular lobe.

Basal antennal article with lateral edge bearing closely-spaced, small, blunt tubercles or spinules, up to six tubercles of various sizes on ventral surface, the largest midway along. Antennae about as long as carapace, segments with long hairs but no spines.

Epistome slightly wider than long, a tubercle laterally just outside and forward of opening of green gland. Pterygostomian regions with a small tubercle on lateral border posteriorly.

Ischium of third maxillipeds with two distally divergent, oblique, ill-defined rows of more or less sharp spines on each side of shallow longitudinal groove; medial edge minutely toothed. Merus with a row of sharp spines lateral to shallow longitudinal groove; lateral and distal edges irregularly crenulate and lobed. Palp long and stout, laterally, medially and apically fringed by long hairs; carpus bearing a strong, slender spine medially towards distal edge, propodus with a similar ventral spine about midway along its length. Exopodite bearing a longitudinal row of small tubercles along its outer surface.

Thoracic sternites in male each bearing transverse groups of small tubercles, a broad band of tubercles along anterior edge of abdominal fossa elevated as two groups, one on each side of midline, several smaller tubercles scattered over anterior sternite.

Chelipeds in male long, meri and chelae robust, spinous and hairy, ischium subtrigonal, merus subtrigonal to subcylindrical, carpus subcylindrical, chela compressed. Ill-defined ventromedial and ventrolateral edges of merus each with a row of irregularly sized small spines and tubercles, those along ventromedial edge longer and more slender, several small tubercles scattered along dorsal surface. Carpus with ill-defined rows of small spines and tubercles. Chela with palm about twice as long as high, closely spaced short spinules along dorsal and ventral surfaces, several short spinules in a poorly defined longitudinal row near middle of inner surface and some tubercles also scattered over outer surface. Fingers slightly shorter than palm, incurved, distally acute and weakly gaping proximally; inner edges toothed, teeth larger proximally. Cheliped of female no longer than carapace, slender; spines, tubercles and hairs on merus, carpus and propodus slightly longer than in male; fingers as long as palm, meeting along cutting edges, very weakly toothed, teeth larger and closer together distally.

Ambulatory legs very long and slender, first the longest, about  $3\frac{1}{2}$  times carapace length, remaining legs decreasing regularly in length, fourth the shortest, about twice carapace length; curled hairs singly along merus, carpus and propodus dorsally. Dactyls of first two legs long and almost straight, weakly curved distally and unarmed, bearing long straight hairs;

dactyls of third and fourth legs weakly curved, bearing about six short spines ventrally along distal half and some low tubercles proximally.

All segments of abdomen in male, except last, wider than long, last segment the longest, as long as wide. Third segment with strongly convex lateral edges, last segment subtriangular, lateral margin convex proximally, distally rounded. Surface elevated in midline, bearing a large, spinulate tubercle on first segment, a wide elevation distally on third to fifth segments and on the last, two central tubercles in the midline, the more distal weakly divided into a transverse pair; third segment laterally inflated, with spinate surface and margins. Female abdomen broad, elongate subovate, elevated in midline, covered by small spinules or tubercles.

Male first pleopod moderately slender except for more bulbous base, abruptly inwardly curved distally, tip rounded; aperture terminal, a long, moderately narrow slit at end of groove extending along sternal surface to become lateral near tip; a group of long, simple hairs midway along medial surface and some shorter hairs opposite on lateral surface, a few long, plumose hairs at base laterally.

*Measurements:* Male (WAM 125-67)—carapace length 5.5 mm, carapace width 3.5 mm, rostrum length 0.7 mm, rostrum width 0.9 mm, cheliped length 8.0 mm, chela length 3.5 mm, chela height 1.2 mm, dactyl length 1.9 mm.

*Remarks:* The specimens from Western Australia agree completely with De Man's detailed description and figures based on three females from Japan.

Rathbun's description of *Achaeus stenorhynchus* was brief and no illustration was given but there can be no doubt that she was referring to De Man's species.

Sakai's description and figures disagree with the Western Australian specimens only in that the first pleopod of the male is shown (text-fig. 12b) as weakly curved distally.

This species shows considerable variation in spinulation. The spinules on the supraorbital cave are sometimes absent, the sides of the large spines of the carapace are sometimes smooth and the spines above the last leg are sometimes topped by a group of spinules.

The carapace has a shorter and less constricted "neck" than the male as is usual in the genus.

*Distribution:* Western Australia; previously known from south-eastern Japan from Sagami Bay to Koshiki Islands near Kuysyu; 43-75 fms.

#### *Achaeus* sp.

Figs 12, 13e, f.

*Material examined:* A total of three specimens as follows:

*Western Australia:* N.W. of Point Cloates, 22°52'S., 113°29'E., triangle dredge, 73 fms, 6/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 178, 1 ♂, 4.5 mm, 1 ♀, 3.8 mm (WAM 71-67). N.W. of Bluff Point, 27°18'S., 113°16'E., triangle dredge, 54 fms, 9/10/1963, HMAS "Diamantina" Cruise 6/63, CSIRO Sta. 204, 1 ♀ (ovig.), 4.6 mm (WAM 130-67).

*Remarks:* A detailed description of these specimens would be premature in view of the few specimens and the absence of chelipeds from the male and of most legs from all specimens. The three specimens are generally similar to *A. lacertosus* but differ in the following features:

- (1) The carapace is covered by close set spinules except anteriorly and there is a metagastric tubercle or spine plus a transverse cardiac pair of tubercles about the same size;
- (2) the rostral spines are without spinules;
- (3) the supraorbital eaves bear close set spinules along their outer margins and there are a few spinules behind;
- (4) the eyestalks each bear three sharp spines on the anterior surface;
- (5) the basal segment of each antennule bears four spines in an oblique row;
- (6) the basal antennal articles bear a row of spinules along both the lateral and medial edges and terminate in a strong anterolateral spine;
- (7) the ischium of the third maxillipeds bears a longitudinal row of spinules on each side of the longitudinal central groove and the merus bears long spines along the medial edge;

(8) the thoracic sternum in the male is spinulose;

(9) the abdomen of the male has stronger medial tubercles, with two prominent ones in the midline on the last segment;

(10) the first pleopod of the male is more expanded distally than is that of *A. lacertosus* and there are only short hairs near the tip; the aperture is protected by a small lateral flap.

The smaller female possesses chelipeds. These are slender but short and the ischium, merus and propodus are provided with long and short spines along the dorsal and ventral surfaces and there are some short spines on the carpus dorsally.

The male has the tip of the dactyl of one ambulatory leg caught among the hairs of the carapace. It is weakly curved with a few short spines ventrally towards the tip. Two ambulatory legs, probably anterior ones, are associated with the specimens. They are provided with long hairs and the dactyl is weakly curved and unarmed.

It is possible that these specimens may belong to *A. robustus* Yokoya to which there are general resemblances in carapace shape and ornamentation and also in the first pleopod of the male (M. Takeda, pers. com.).

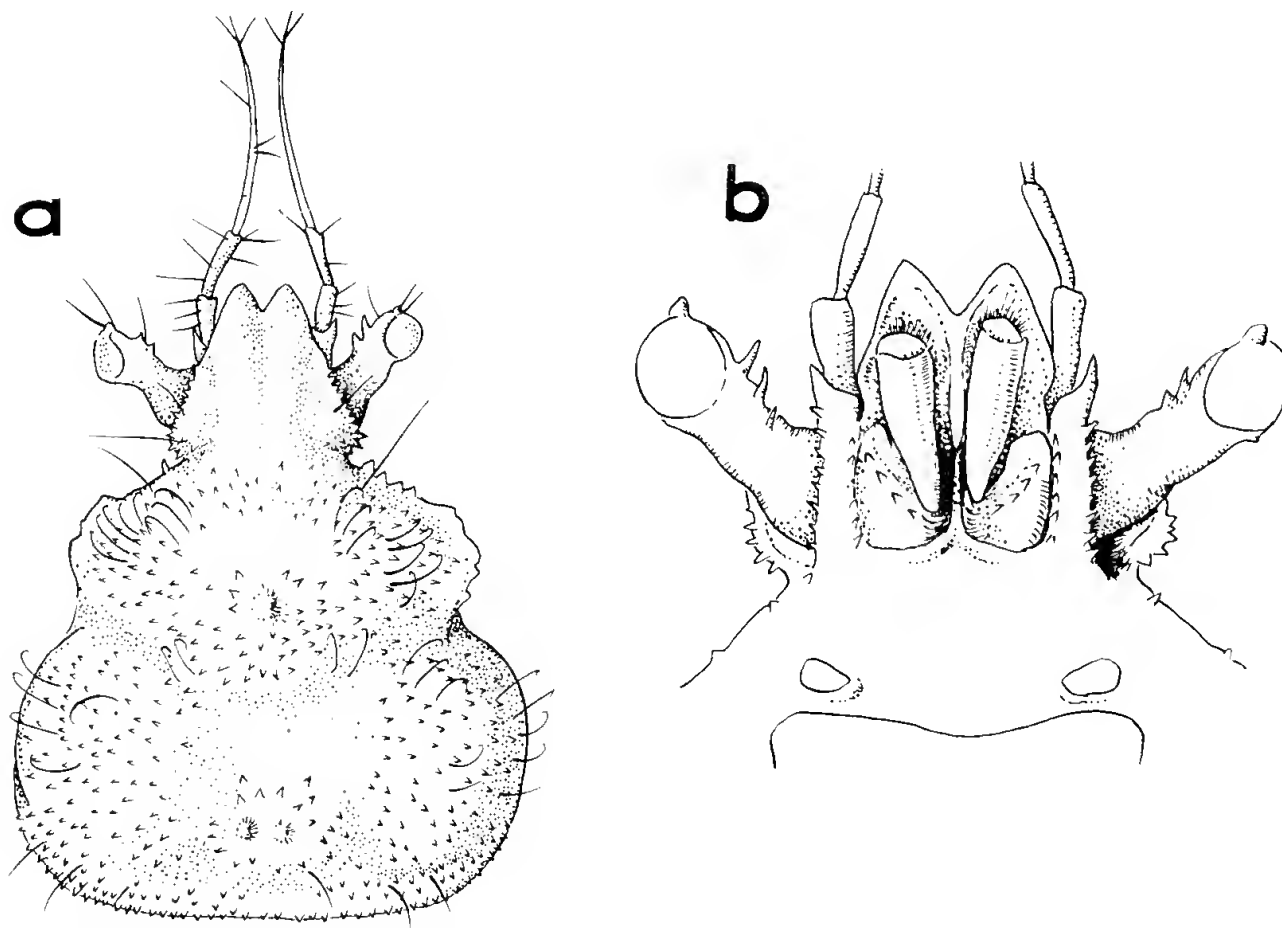


Figure 12.—*Achaeus* sp., male, 4.5 mm, N.W. of Point Cloates, W.A. (WAM 71-67). a, carapace, dorsal view; b, front of carapace, ventral view.

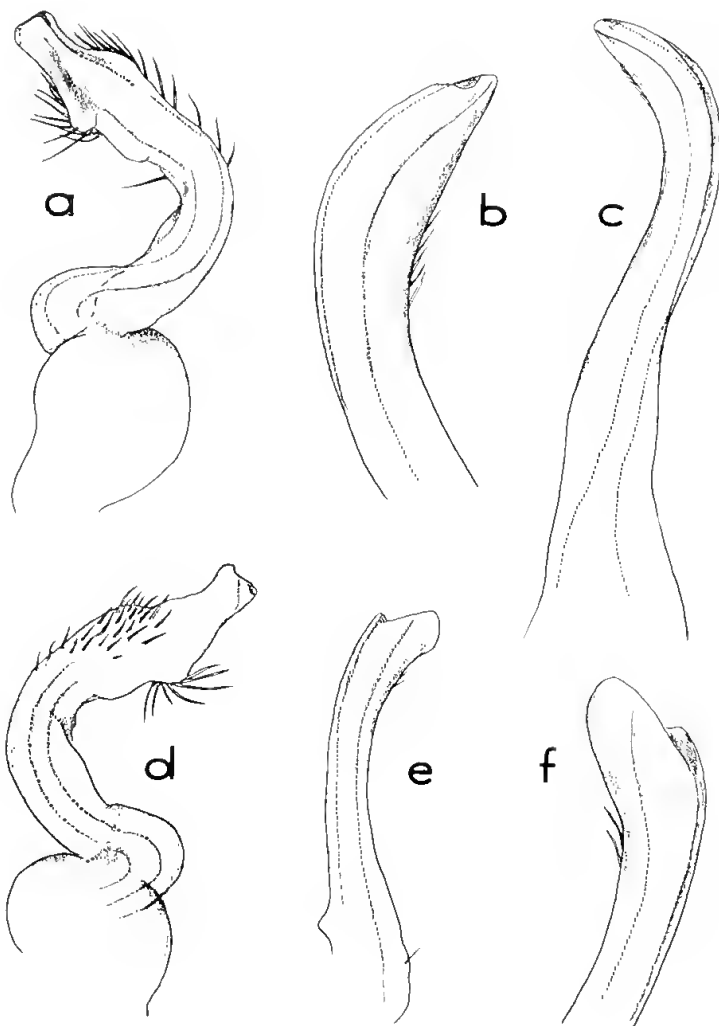


Figure 13.—Male left first pleopods of *Achaeus galathea*, n.sp., *A. fissifrons* (Haswell) and *Achaeus* species. a, d, *A. galathea*, PARATYPE, 3.3 mm (CM); b, c, *A. fissifrons*, 10.0 mm, Port Jackson, N.S.W. (AM P.1442); e, f, *Achaeus* sp., 4.5 mm (WAM 71-67), a, c, e, abdominal surface; b, d, f, sternal surface.

### Discussion

The genus *Achaeus* appears to comprise two or possibly three subgroups. In the majority of the species the first pleopod of the male is weakly curved distally and the aperture is a simple subterminal or sometimes terminal slit. In a second group, *A. podocheloides*, a new species from Japan and the unidentified species discussed in this report, the subterminal aperture is protected by a membranous flap, a feature not commonly found in Indo-Pacific inachines but known in a number of Atlantic and east Pacific forms and several Indo-Pacific majines. In a third group, comprising *A. suluensis* and *A. galathea* the pleopod is strongly twisted and quite different from that of any other known majid. These differences generally are not well correlated with other morphological features, however.

The seven named Australian species fall into three distributional groups. One, comprising *A. lacertosus* and *A. brevirostris*, is distributed around western, northern and eastern Australia and also has a widespread Indo-West Pacific

distribution. Another, comprising only *A. fissifrons*, occurs off south-western and south-eastern Australia but is not known from northern Australia. This is also widespread in the Indo-West Pacific. The third group comprises species known from either north-western Australia (*A. podocheloides* and *A. pugnax*) or north-eastern Australia (*A. paradisei* and *A. galathea*) but not both. These four species either occur also in Japan or are closely similar to Japanese species.

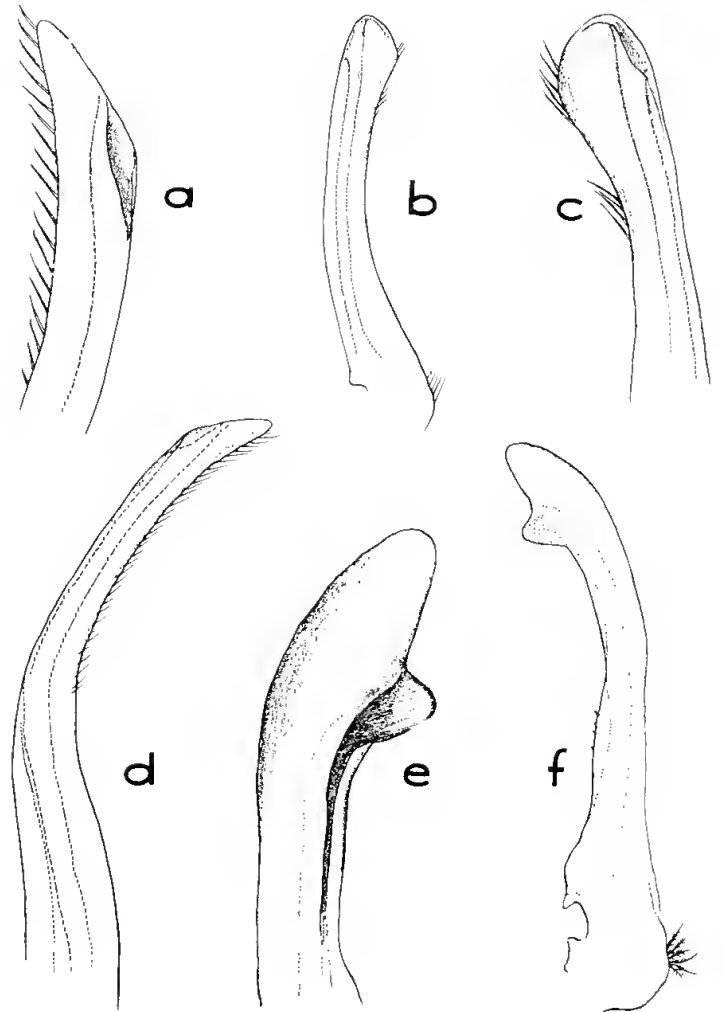


Figure 14.—Male left first pleopods of *Achaeus lacertosus* Stimpson, *A. brevifalcatus* Rathbun and *A. podocheloides* n.sp. a, d, *A. lacertosus*, 10.4 mm, Port Stephens, N.S.W. (AM P.162); b, c, *A. brevifalcatus*, LECTOTYPE; e, f, *A. podocheloides*, HOLOTYPE. a, b, f, abdominal surface; c, d, e, sternal surface.

### Acknowledgments

It is a pleasure to thank the following individuals for making available collections under their care, for advice on type, material and other matters: R. W. George (Western Australian Museum, Perth), A. L. Rice (British Museum (Natural History), London), T. Wolff (Universitetets Zoologiske Museum, Copenhagen), H. B. Roberts (U.S. National Museum, Washington), M. Takeda (Zoological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka), B. M. Campbell (Queensland Museum, Brisbane) and Helene M. Laws (South Australian Museum, Adelaide).

Travel to the Queensland and Western Australian Museums was made possible by a research grant from the C.S.I.R.O. Science and Industry Endowment Fund.

Finally, I am especially grateful to Mr Takeda and to Dr J. C. Yaldwyn (Dominion Museum, Wellington) for helpful discussion of some of the problems involved in this study.

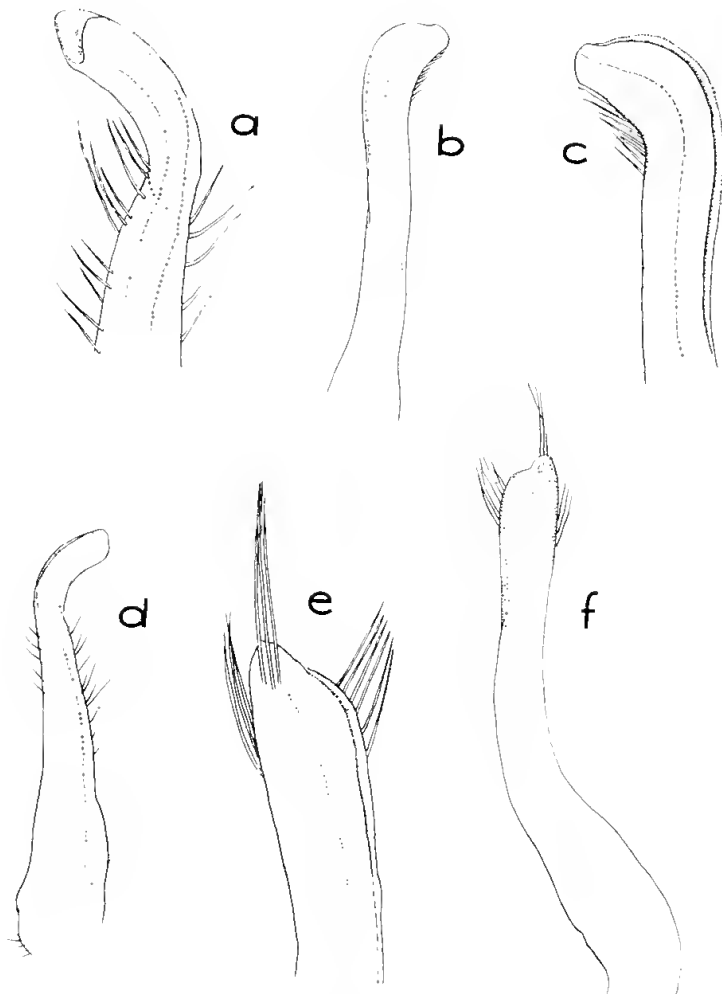


Figure 15.—Male left first pleopods of *Achaeus pugnax* (De Man), *A. paradisei* n.sp. and *A. brevisrostris* (Haswell). a, d, *A. pugnax*, 5.6 mm, N.W. of Carnarvon, W.A. (WAM 167-67); b, c, *A. paradisei*, HOLOTYPE; e, f, *A. brevisrostris*, 11.4 mm, Port Denison, Qld (AM P.16584). a, c, f, abdominal surface; b, d, e, sternal surface.

## References

- Buitendijk, Alida M. (1950).—On a small collection of Decapoda Brachyura, chiefly Dromiidae and Oxyrhyncha, from the neighbourhood of Singapore. *Bull. Raffles Mus.* 21: 59-82.
- Griffin, D. J. G. (1966a).—The marine fauna of New Zealand: spider crabs family Majidae (Crustacea, Brachyura). *Bull. N.Z. Dep. scient. ind. Res.* 172: 1-112, 23 figs., 4 pls.
- (1966b).—A review of the Australian majid spider crabs (Crustacea, Brachyura). *Aust. Zool.* 13: 259-298, 3 figs, pls. XV-XVII.
- (1968).—Two new species of *Achaeus* (Crustacea, Decapoda, Majidae) from South Africa. *Ann. S. Afr. Mus.* 52: 75-87, 4 figs.
- (in press).—Dr. Th. Mortensen's Pacific Expedition 1914-16. Crustacea Brachyura from eastern and southern Australia. Steenstrupia.
- Griffin, D. J. G. and J. C. Yaldwyn (1965).—A record of the majid brachyuran genus *Achaeus* from New Zealand with notes on the Australian species. *Trans. R. Soc. N.Z., Zool.* 6: 33-51, 8 figs.
- Haswell, W. A. (1879).—On two new species of the genus *Stenorhynchus*. *Proc. Linn. Soc. N.S.W.* 3: 408-409.
- Man, J. G. De (1928).—Papers from Dr Th. Mortensen's Pacific Expedition 1914-16. XLII. On four species of crabs of the families Inachidae and Xanthidae, two of which are new to science. *Vidensk. Meddr. Dansk. naturh. Foren.* 85: 7-25, 4 figs.
- Miers, E. J. (1884).—Crustacea. In "Report of the zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. "Alert" 1881-2": 178-322, 513-575, pls. XVIII-XXXIV, XLV-LII. London: British Museum (Natural History).
- (1886).—Report on the Brachyura collected by H.M.S. "Challenger" during the years 1873-1876. *Rep. Voy. "Challenger"*, Zool. 17: 1-362, 29 pls.
- Rathbun, Mary J. (1906).—The Brachyura and Macrura of the Hawaiian Islands. *Bull. U.S. Fish. Comm.* 23: 827-930, 79 figs, pls 3-25.
- (1911).—The Percy Sladen Trust Expedition to the Indian Ocean in 1905: Marine Brachyura. *Trans. Linn. Soc. Lond. (Zool.)* (ser. 2) 14 (2): 191-261, pls XV-XX.
- (1916).—Scientific results of the Philippine cruise of the fisheries steamer "Albatross" 1907-1910. No. 34. New species of crabs of the families Inachidae and Parthenopidae. *Proc. U.S. Natn. Mus.* 50: 527-559.
- (1932).—Preliminary descriptions of new species of Japanese crabs. *Proc. biol. Soc. Washington* 45: 29-38.
- Sakai, T. (1938).—Studies on crabs of Japan. III. Brachygnatha, Oxyrhyncha: 193-364, 55 figs, 51 pls. Tokyo: Yokendo Co.
- (1965).—The crabs of Sagami Bay collected by His Majesty The Emperor of Japan. Tokyo: Maruzen. Pp.i-xvi, 1-206, 1-26 (English), 1-92, 27-32 (Japanese), 26 figs, 100 pls, 1 map.
- Stephensen, K. (1945).—The Brachyura of the Iranian Gulf, with an appendix: the male pleopoda of the Brachyura. *Danish sci. Invest. Iran* 4: 57-237, 60 figs.
- Stimpson, W. (1857).—Prodromus descriptionis animalium cvertebratorum, quae in Expeditione ad Oceanum Pacificum Sententrialem, e Republica Federata missa, C. Ringgold et J. Rodgers Ducibus, observavit et descripsit. Pars III. Crustacea Maloidea. *Proc. Acad. nat. Sci. Philad.* 9 (25): 216-221.
- Terazaki (1902).—An introduction to Japanese crabs (In Japanese). No. 10. *Zool. Mag. Japan* 14: 400-401.
- Yokoya, Y. (1933).—On the distribution of decapod crustaceans inhabiting the continental shelf around Japan, chiefly based upon the materials collected by S.S. "Sôyô-Marû", during the year 1923-1930. *J. Coll. Agric. Tokyo Imp. Univ.* 12: 1-226, 71 figs.

# 11.—Permian Brachiopod *Retimarginifera* n. gen. n. sp. from the Byro Group of Carnarvon Basin, Western Australia

by J. B. Waterhouse\*

Manuscript received 20 May, 1969; accepted 19 May, 1970.

## Abstract

A Productid species from the Permian Byro Group of the Carnarvon Basin, which was previously referred to *Dictyoclostus gratus* (not Waagen) by Prendergast (1943) and to *Marginifera gratiodentalis* (not Grabau) by Coleman (1957) is described as *Retimarginifera perforata* n. gen. n. sp. The genus is classed in the Paucispiniferinae Muir-Wood and Cooper 1960, which is transferred from the Linoproductidae to the Marginiferidae. Muir-Wood and Cooper's definitions of other Marginiferid subfamilies are emended.

## Introduction

In 1966 Dr. P. J. Coleman, Department of Geology, University of Western Australia, kindly loaned me a collection of Marginiferid shells from the Permian Byro Group of the Carnarvon Basin, Western Australia. These had previously been referred to *Marginifera gratiodentalis* Grabau but Grabau's species is not conspecific, belonging to the Dictyoclostidae, whereas the West Australian specimens belong to the Marginiferidae.

## Stratigraphy

The specimens described herein come from the Cundlego Formation in the middle part of the Byro Group in the Carnarvon Basin (Fig. 1). Further occurrences have been reported by Coleman (1957) from the slightly younger Wandagee Formation, and also from the Baker Formation at the top of the Byro Group, or from the Coolkilya Greywacke at the base of the overlying Kennedy Group. Condon (1967, p. 169) listed *M. gratiodentalis* from the Wandagee Formation, Norton Greywacke, and the Coolkilya Greywacke (p. 184), with no mention of it in the Baker Formation. Elsewhere he emphasised that it, with other species, is "found no higher than the Baker Formation" (p. 156) and this is correct, according to a letter from Mr. Condon (in litt, November, 1968). There has been confusion over the limits of the top of the Byro Group and the Coolkilya Formation, because Condon (1954, p. 85) put the base of the Coolkilya much higher than proposed by Teichert (1950, 1957), as outlined by Dickins (1963). The outline presented by Dickins (1963) as amended by Condon (1967) is followed herein because this was the order in which the collections were arranged when assessed by the writer at the Bureau of Mineral Resources.

### Correlation of the Lower Byro Group (Stage D 1)

New Zealand, eastern Australia—Dickins (1963) recognised two faunas in the Byro Group, both referred to Stage D. D 1 is found in the

lower formations of the Byro Group up to and including the Wandagee Formation (Fig. 1). To judge from fossil lists presented by Dickins (1963, p. 14) and Coleman (1957), and examination of collections at the Bureau of Mineral Resources, Geology and Geophysics, Canberra, during April 1963, the D 1 fauna is distinguished by the diversity of genera, such as *Kiangsella*, *Waagenoconcha*, *Lialosia*, *Fusispirifer* and other transverse spiriferids, *Yochelsonia*, *Hoskingia*, *Glyptoleda*, *Heteropeeten*, *Palaeocosmomya*, *Girtypeeten?*, *Acanthopeeten?*, *Stachella?*, *Bel-lerophon*, *Macrochilina*, *Euphemites* and *Straparollus*. Cold water genera especially typical of eastern Australia such as *Deltopecten*, *Eurydesma* and *Keeneia* are not known at this horizon.

A few brachiopods, notably *Echinalosia prideri* (Coleman) and *Aulosteges ingens* Hosking which are especially characteristic of the lower Byro Group and equivalent horizons of Western Australia are found in the upper Takitimu Group of New Zealand (Waterhouse 1967). This correlation is reinforced by the approach of the underlying Telfordian faunas of New Zealand to the Callytharra-Wooramel faunas below the Byro Group in the Carnarvon Basin, and of the overlying Braxtonian faunas of New Zealand to the D 2 faunas in the Carnarvon Basin, as shown in Table 1.

Urals. (World Standard)—Various formations within the lower Byro Group, up to and including the Wandagee Formation, have yielded Baigendzinian (=upper Artinskian, ?Kungurian) ammonoids (Glenister and Furnish, 1961). Thomas and Dickins (1954) correlated the faunas with those of the Lower Productus Limestone of the Salt Range, which accords well with the ammonoid evidence.

### Correlation of the Upper Byro and Lower Kennedy (Stage D 2)

Dickins (1963) separated the upper Byro faunas of the Norton Greywacke and Baker Formation from the D 1 faunas of older horizons, and referred the faunas of the overlying Coolkilya Greywacke at the base of the Kennedy Group to the same D 2 substage. The writer examined the collections at the Bureau of Mineral Resources, Canberra, and fully agrees with this distinction, though preferring to see the difference upgraded to stage rank. At the D 1-D 2 boundary *Taeniothaerus* and many Strophalosiids disappeared, together with molluscs such as *Platyceras?*, *Nuculanella?*.

\* Department of Geology, University of Toronto, Canada.

\* Asterisked species reappeared in the Coolkilya Greywacke.

TABLE 1

Correlation of Permian sequences. The lower Texan stages should be subdivided, and the Skinner Ranch included with the Lenox Hills

Russian Standard	Ammonoid Subdivisions in Russia	Western Australia		United States, Texas		New Zealand Stages
		Carnarvon Basin Formations	Stages Dickens (1963)	Glass Mts. Formations	Stages	
Tatarian				Ochoan		Makarewan
						Waitian
		Kennedy Group	F	Capitan	Capitan	Puruhanan
Kazanian			E	Word	Wordian	Braxtonian (Flettian)
Ufimian	(no ammonoids)		D <sub>2</sub>	Road Canyon	Roadian	(Barrettian)
	(few ammonoids)	Byro Group	D <sub>1</sub>	Cathedral Mountain	Leonard	Mangapirian
	Baigendzinian					
Artinskian	Aktastinian	? Wooramel Group	C	Skinner Ranch		Telfordian
	Sakmarian	Callytharra Form	B	Lenox Hills		
Sakmarian	Asselian	Lyons Group	A	Neal Ranch	Wolfcamp	Horizon B
						Horizon A

*Quadratonucula*, *Peruvipsira*, *Chaenomya*, *Lep-tomphalus*\*, *Macrochilina*\*, *Nuculopsis*\*, *Paleo-solen*\*, *Pseudobaylca*\*, *Naticopsis*, *Plagiostroma*\*, *Acanthopecten*, *Astartella*, *Allorisma*, *Hetero-pecten*\*, *Megadesmus* also dropped out accord-ing to the lists in Dickens (1963), but is probably represented as so-called *Cardiomorpha blatch-fordi*. Genera such as *Warthia*, *Schizodus* and *Cancrinella* also persisted.

Glenister and Furnish (1961) have sug-gested on the basis of ammonoids that the Cool-kilya Formation, including upper Byro as defined by Teichert, ranged from Baigendzinian into the lower Guadalupian (including basal Word). Dickens (1956, 1963) referred the upper Byro to the upper Artinskian, and Coolkilya (restricted) to the Kungurian. Changes are now necessary to these ages, because of redefinitions and subdivisions within the standard sections of North America and Russia. In the Glass Mountains, Texas, the standard sequence for North Ameri-can Permian, the lower Guadalupian of Glenis-ter and Furnish has been replaced in the new Road Canyon Formation by Cooper and Grant (1964), and recognised as a possibly distinct brachiopod stage by Nassichuk et al (1965), called Roadian by Furnish (1966 Table 1, p. 269). The Russian world standard has also been reinterpreted. When Dickens (1963) pro-posed a Kungurian age for the Coolkilya Formation he accepted the views of Licharev (1959) and others that the Kungurian Stage was followed by the Kazanian Stage, and that an intervening so-called Ufimian Stage should not be recognised. However the Soviet Com-mission on Permian Stratigraphy has set aside this view, and officially recognised the Ufimian

Stage (Licharev 1966). They have also low-ered the Kungurian boundary. Thus the Kun-gurian correlation needs to be readjusted to the new Soviet interpretation. Waterhouse (1969 b) showed that the Ufimian as now understood rather than Kungurian was prob-ably equivalent to the Road Canyon, upper Byro and other faunas. Certainly there is a very distinct pre-Kazanian fauna, with charac-teristic fusulinids, brachiopods and ammonoids, developed widely above Baigendzinian faunas in Siberia, Arctic Canada, China, Japan, Aus-tralia and New Zealand. This fauna is pres-ent in the upper Byro Group. It possibly in-cludes the Coolkilya fauna as well, though Dickens (1956) did compare several bivalves with species from the Basleo beds of Timor. The Basleo beds are of Wordian (Kazanian) age, but Dickens considered that the affinities indi-cated a post-Artinskian age, and that absence of certain key genera ruled out a Kazanian correlation (Dickens, 1956, p. 39).

### Systematic description

#### Order Productida

#### Family Marginiferidae Stehli 1954

#### Diagnosis

Marginal ridge well defined in both valves or dorsal valve, cardinal process sessile to erect, broad median shaft, narrow backleaning median lobe and broad lateral lobes, costellae of variable strength, spines in row along hinge and/or umbonal slopes, specialised into very sturdy regularly arranged halteroid spines in some genera, comparatively few over visceral disc and trail, present or absent on dorsal valve. Muscle scars usually not dendritic or lobate.

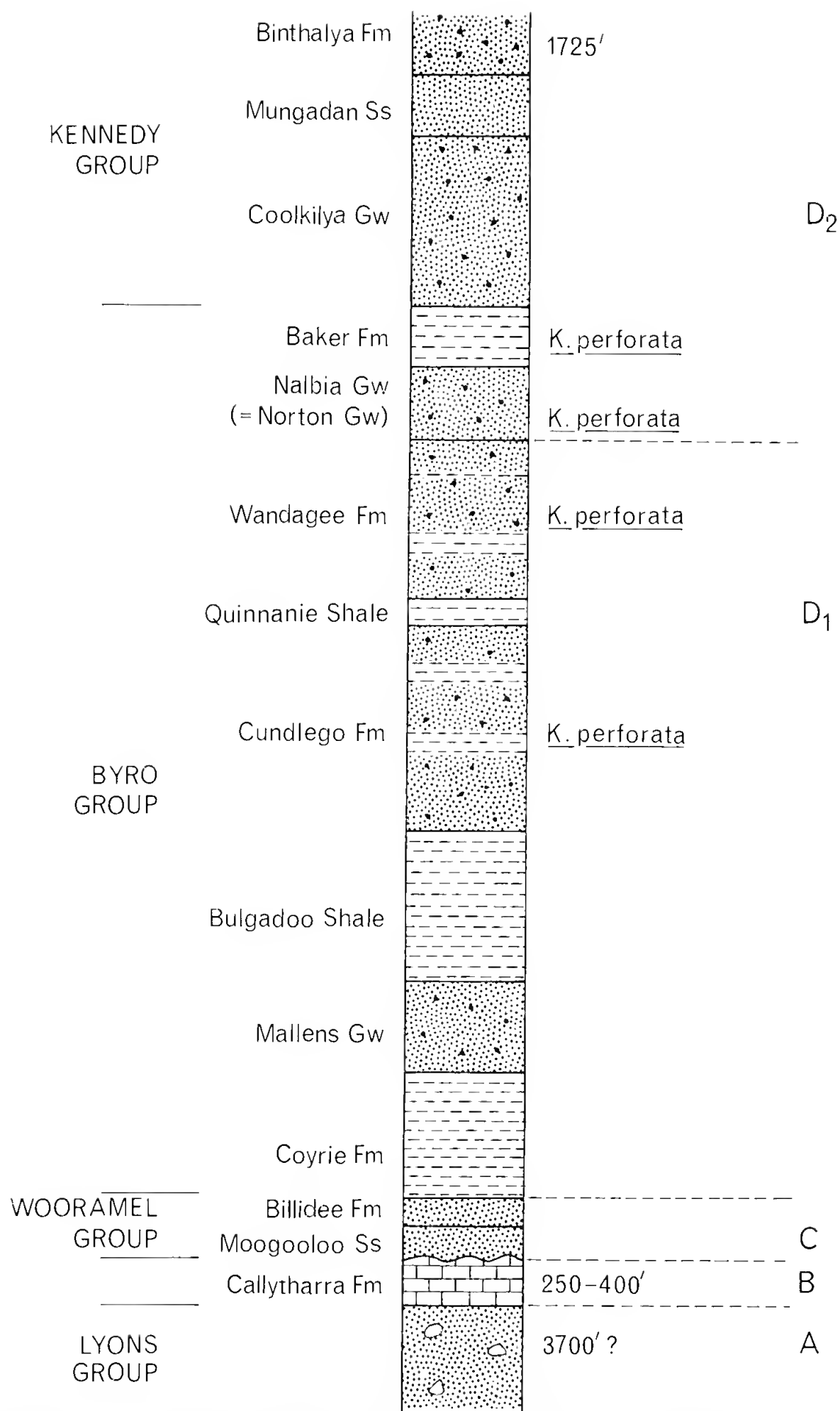


Fig. 1.—Sequence of formations in Carnarvon Basin, showing occurrences of *Retimarginifera perforata* n. sp., and subdivision of faunal stages by Dickins (1963), based on Dickins (1963, fig. 2).

### Subfamily classification

Muir-Wood and Cooper (1960), followed by Muir-Wood (1965), recognised four subfamilies in the Marginiferidae partly on shape, partly on the presence or absence and strength of the marginal ridges. Their classification is not always consistently applied. For instance the Marginiferinae was defined as having a continuous externally crenulated marginal ridge around the dorsal valve, and smooth adductors, in contrast to the Costispiniferinae, with crenulated ridges across the ears of both valves, and prominent endospines and smooth or rarely dendritic adductors. However *Marginifera* and *Hystericulina* do have marginal ridges across the ears of both valves, so that the definition of Marginiferinae erred. Endospines occur in the genus *Kozlowskia*, yet this is classed in the Marginiferinae. *Elliottella* was described as having no marginal ridge in the ventral valve (Muir-Wood and Cooper, 1960, p. 224), and *Liosotella* as having no marginal ridge in the dorsal valve (Muir-Wood and Cooper, 1960, p. 228), yet both were classed in the Costispiniferinae. In fact, examination of the type species at the Smithsonian Institution shows that marginal ridges are present in both valves of both *Elliottella* and *Liosotella*.

The subfamily Paucispiniferinae was classed in the Linoproducidae by Muir-Wood and Cooper (1960) and Muir-Wood (1965). *Paucispinifera*, as clearly shown in illustrations by Muir-Wood and Cooper (1960, pl. 122, figs. 1-16) and confirmed from examination of types at the Smithsonian Institution, Washington, has a marginal ridge in both valves, a characteristic cardinal process with narrow median lobe, a peculiar structure called a zygidium, found also in the Marginiferid genus *Kozlowskia*, smooth adductor scars, and transversely arranged large halteroid spines. These features are typical of the Marginiferidae, not of the Linoproducidae, and the subfamily should be classed with the Marginiferidae (Waterhouse, 1969a, p. 232). The genus is distinguished in part by its cardinal process, which at least in the type species *P. auriculata* Muir-Wood and Cooper examined at the Smithsonian Institution has an anteriorly extended median lobe. Otherwise, its most characteristic feature lies in the symmetrically disposed large halteroid spines across the ventral valve. The same spine pattern is seen in *Kozlowskia*, and some other genera referred to the Marginiferinae and Costispiniferinae by Muir-Wood and Cooper, but is not present in either *Marginifera*, or *Costispinifera*. In view of this, and because of the fact that the development of marginal ridges in these forms does not accord well with the arrangement of genera in Muir-Wood and Cooper, the three subfamilies are redefined as follows, using spines as the chief guide for classification.

A. Marginiferinae: Marginiferidae with spines restricted to ventral valve, not differentiated into transverse row of about six large halteroid spines, halteroid spines arranged in radial rows over umbonal slopes.

*Marginifera*, *Anemonaria*, *Hystericulina*, *Liosotella*, ?*Elliottella* *Anemonaria*.

B. Paucispiniferinae: Marginiferidae with spines restricted to ventral valve, characterised by three to six large halteroid bracing spines developed in one of three concentric rows across shell.

*Paucispinifera*, *Kozlowskia*, ?*Alifera*, *Eomarginifera*, *Paramarginifera*, *Retimarginifera*, *Probolionia* closely allied, *Sajakella*.

*Yakovlevia* and *Muirwoodia*, referred to the Paucispiniferinae by Muir-Wood and Cooper (1960), and *Duartia*, referred to the Marginiferinae by Muir-Wood (1965) are not Marginiferid.

C. Costispiniferinae: Marginiferidae characterised by spines on both valves, not differentiated into few large regularly arranged halteroid ones on ventral valve. *Costispinifera*, *Desmoinesia*, *Echinauris*, *Promarginifera*, *Spinomarginifera*.

*Inflata* and *Nudauris* are not Marginiferid, as claimed by Muir-Wood and Cooper (1965) but are Dictyoclostid.

### Subfamily Paucispiniferinae Muir-Wood and Cooper

Genus *Retimarginifera* n. gen.

Type species.—*Retimarginifera perforata* n. sp.

Diagnosis.—Transverse shells with large ears, deep ventral sulcus, well defined dorsal fold. Halteroid body spines, usually in one to three transverse rows of 4 to 8, as well as row of hinge spines, limited to pedicle valve. Posterior disc reticulate, costae and concentric rugae strong, sturdy marginal ridge in both valves, marginiferid cardinal process, smooth adductors, large endospines.

### Discussion

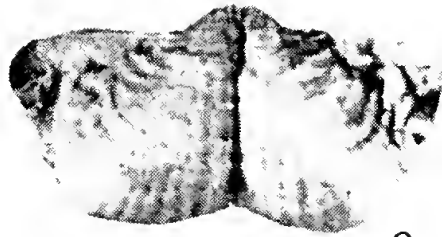
*Kozlowskia* Frederiks, with type species *Productus capacii* D'Orbigny is more globular than the new genus, and has a shallower sulcus and less prominent concentric and radial ornament. The sulcus and fold are less defined, or absent.

Fig. 2.—1-11, *Retimarginifera perforata* n. gen. n. sp. 1-9 external aspects of ventral valves, x 2. 1, 5 specimen 59281 from locality UWA 29401 under different lighting. 2, holotype specimen 59282 from locality 27185, showing spines. 3, specimens 59283 from locality UWA 27185. 4, 8, posterior and anterior aspects of specimen 63828 from WC 20.1, showing extensive ears, with single large spine base. 6, specimen 56384 from locality UWA 27185c. 7, specimen 56385 from locality UWA 27185. 9, specimen 56356 from UWA 27185h, with halteroid spine base on each ear. 10, transverse thin section of pedicle valve 63829 from locality UWA 29401, across sulcus, with external surfaces on top, showing slightly wavy lamellae of secondary layer, penetrated by taleolae (+). Note suggestion of inner pustule (arrowed), x 3 approx. 11, transverse thin section of dorsal valve of same specimen, exterior to right, x 35.

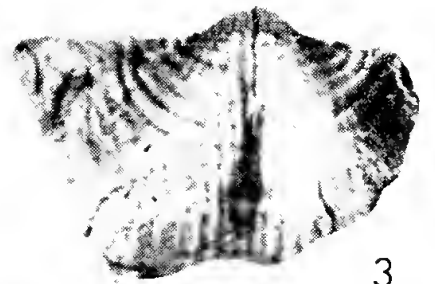
12, "*Productus*" *himalayense* Diener, transverse thin section of ventral valve showing lamellar secondary shell with scattered pustules (arrowed), and an inner prismatic layer. Specimen collected by Dr. Gerhard Fuchs, Geologische Bundesanstalt, Vienna, from Kashmir. x 25.



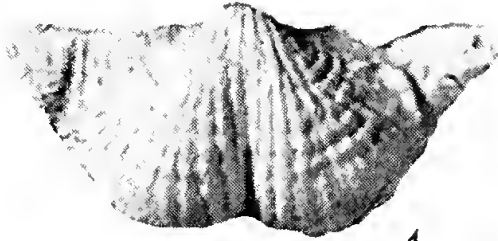
1



2



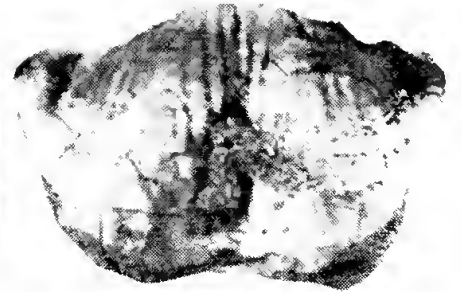
3



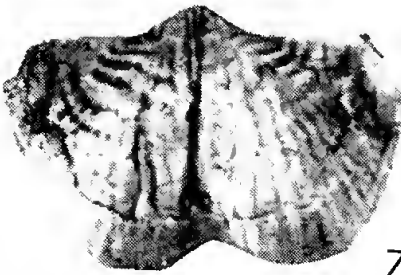
4



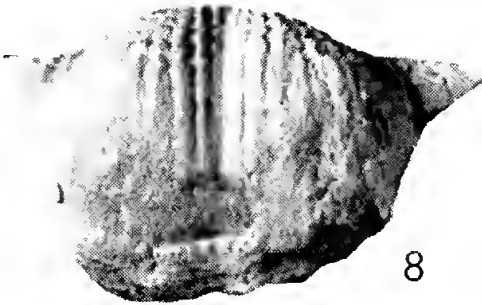
5



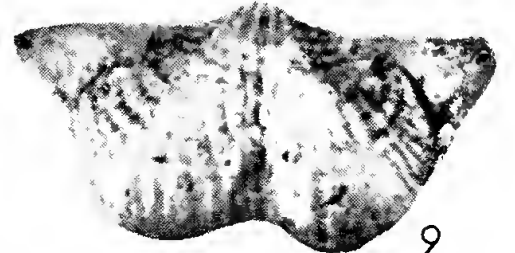
6



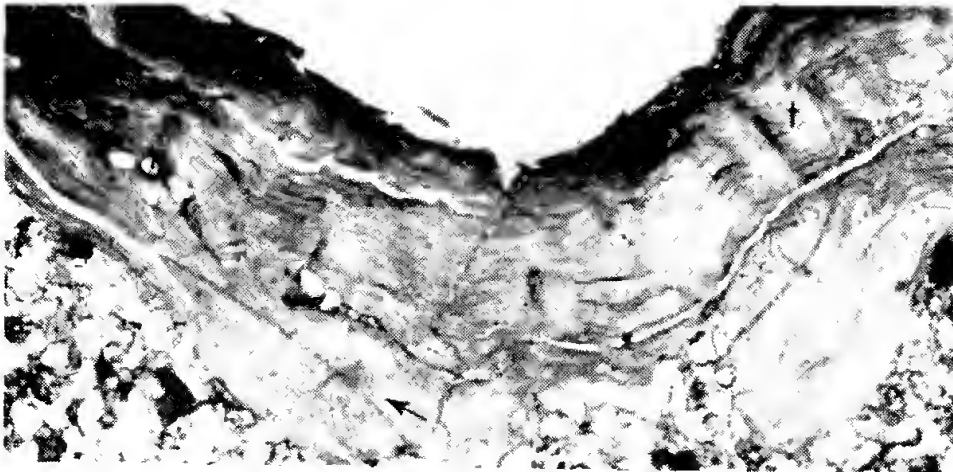
7



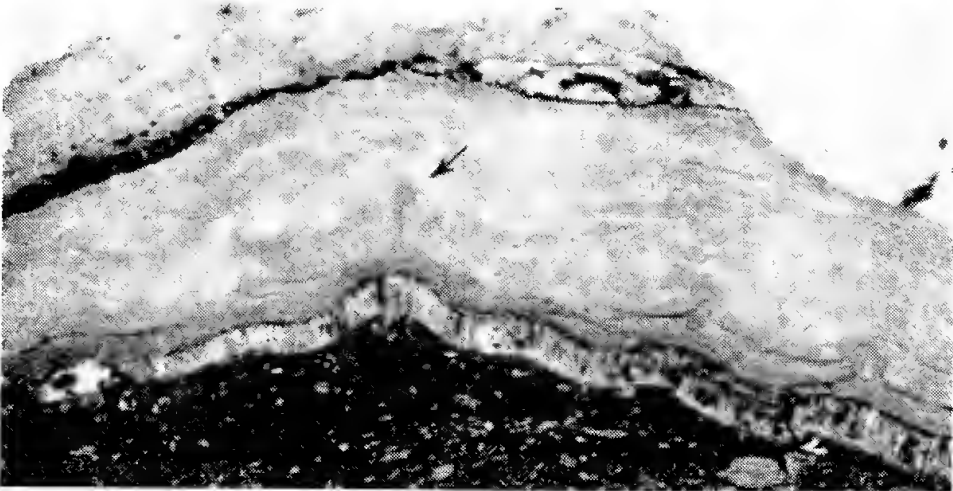
8



9



10



12



11

*Paucispinifera* Muir-Wood and Cooper 1960, based on *P. auriculata* Muir-Wood and Cooper, is closer in general shape, and has moderately well defined costae, but concentric ornament and sulcus are inconspicuous.

The genus is possibly represented by *Productus altimontanus* Merla, *P. rimuensis* Merla, *Marginifera hoofti* Renz in the Karakorum and *Marginifera pusilla* Schellwien in south-east Europe, all of Lower Permian age.

*Retimarginifera perforata* n. sp.

Figs. 2, 1-11, 3

*Dictyoclostus graciosus* Prendergast (not Waagen) 1943: p. 17, pl. 2, figs. 5-7.

*Marginifera gratiodentalis* (not Grabau) Coleman 1957: p. 79, pl. 9, figs. 1-14.

*Kozlowskia* n. sp. Waterhouse 1969 a: p. 232, Fig 41.

**Material.**—Material examined by the writer comprises two specimens with valves conjoined and three ventral valves from UWA 29401, a figured dorsal valve UWA 28453a; seven ventral valves, and one specimen with valves conjoined (the dorsal one masked), from UWA 27185, and a block WC 20.1 with four ventral valves, all kept at University of Western Australia. The shell material is preserved, slightly worn and decorticated sufficiently to obscure external growth lamellae and interior pustulation. Many have lost the anterior trail, and cardinal extremities. Coleman's description was based on these and a further 35 or so specimens, kept at the University of Western Australia. Prendergast based her description on five specimens, kept at the Australian Museum, Sydney.

**Localities.**—UWA 27185—Cundlego Formation, *Calceolispongia* stage horizon north-east side of syncline on north bank of Minilya River, west of Cookkilya Pool, WC 20.1, *Dictyoclostus* zone, same description. UWA 28453—Cundlego Formation, 350 yards west of fence between Barrabiddy and Weer Paddocks, 2220 yards south of gate in the fence near Barrabiddy Creek south of Wandagee Station. UWA 29401, Cundlego Formation—locality 1, horizon 1, of C. Teichert, Wandagee area. Other localities for specimens not examined by the writer are recorded by Coleman (1957, p. 79), including occurrences in both the Wandagee Formation and Baker Formation, Western Australia.

**Holotype.**—Specimen 59282 from locality UWA 27185, fig. 2, 2.

**Figured topotypes.**—Specimens 59283-29286 from locality UWA 27185.

**Diagnosis.**—Transverse alate shells with sulcus deep anteriorly, costellae and wrinkles well developed, endospines elongated. Inner shell penetrated by large taleolae.

**External features.**—The species has been carefully described by Prendergast (1943) and Coleman (1957). Salient features are the transverse outline and prominent ears, set off in the dorsal valve of the holotype by a low ridge. A deep ventral sulcus commences 3-5 mm in front of the umbonal tip, widens rapidly to the start of the trail, and then becomes parallel-sided with a reduced sinistral angle. The fold is

anteriorly placed, the trail high and geniculate. Five to seven costae occur in 5 mm, increasing by branching and implantation, with low well rounded crests. One or two pairs may converge within the sulcus. Ears are smooth. About 15 growth rugae lie over the visceral disc, better defined in the specimens from locality UWA 27185, dividing radial ornament into tubercles, as in *Dictyoclostidae*. The rugae are less pronounced over the anterior disc, and missing or faint over the trail. Growth laminae are also present, about 5 mm per millimeter. Spines arise abruptly from costal crests, reach 1 mm in diameter through this varices, and are restricted to ventral valve. They form three rows, one along the hinge, and one row of usually three or so spines each side of the umbono just inside the ear, and 2-5 spines in a more erratic row each side of the sulcus. A pair of large halteroid spines lies on the ears, a pair on the posterior umbonal flanks, and an anterior pair on the sulcal flanks (Fig. 3). Other spines are few, with some anteriorly as in a specimen from UWA 29401 (Fig. 2, 1).

**Internal features.**—Coleman described the ventral adductor muscle scars as an undifferentiated non-dendritic pair. A low marginal ridge crosses the inner ears and is visible anteriorly in the holotype.

The dorsal valve has a sessile cardinal process with elevated median shaft, broad lateral sulci, and very low lateral lobes. A broad platform lies in front of the process, passing into a short median septum which is highest at its anterior end. The posterior adductor scars are obscure, the anterior adductors small, rounded, anteriorly placed, not dendritic. Brachial ridges are well rounded, and not clearly connected with the septum. The marginal ridge lies just within the hinge, strongly pocked across the inner ears, and faintly defined in front. About 8 elongated, narrow crested endospines lie each side of the midline between the septum and brachial ridges, immediately behind the marginal ridge.

**Shell structure.**—The decorticated shell of several specimens from localities UWA 27185 and 29401 is flocked with white taleolae, 0.3 mm or more apart, and matrix-filled pores of similar spacing, rare posteriorly, and more common anteriorly, presumably later plugged by the taleolae. Pores and taleolae are only 0.1 to 0.2 mm apart in a large worn shell from UWA 29401. A polished transverse surface of a pedicle valve 1 mm thick from UWA 29401 has about 20 thick laminae, with large taleolae normally about 0.3 mm apart, extending from the inner surface half-way into the shell. Thin sections

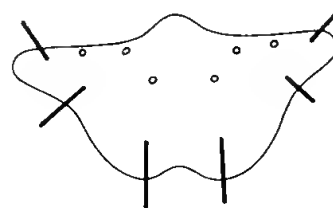


Fig. 3.—Generalised sketch of pedicle valve of *Retimarginifera perforata* n. sp. showing distribution of halteroid spines, functional in black, non functional and old in open circles. x 1 approx.

of another more complete specimen (Fig. 2, 10) show numerous fine lamellae parallel to outer surface, interrupted by the large calcareous rods (taleolae), usually 0.10 mm across, and larger pores with matrix-filled cores, and the lamellae bulging inwards to each side. An innermost zone of smooth tissue is present, with large pustules doming outwards, only 0.7 to 1 mm apart, seemingly too numerous for spine bases. There are no visible taleolae.

A transverse thin section of the dorsal valve (Fig. 2, 11) 0.5 mm thick, is made up of numerous parallel lamellae with a thin outer yellowish band 0.05 mm thick of 2 to 5 lamellae. The inner edge is embayed by large pustules, and rare taleolae are visible in the inner layer, with a couple extending into the outer layer, but not disturbing the laminate structure.

Other Productida have an outer layer with dense taleolae, but no tubes and pores, examples including other Paucispiniferinae (Fig. 2, 12) *Anidanthus* (Waterhouse, 1968a) and *Kuvelousia* (Waterhouse, 1968b). (See Waterhouse 1970, p. 47.)

*Prendergast's specimens*.—These specimens, examined at the Australian Museum, Sydney, appear to be closely related and perhaps conspecific, but the types were not to hand for comparison. The figured specimen F 37569 (Prendergast, 1943, pl. 2, figs. 5-7) has spines, whereas the unfigured F 37570 has more body spines, and no obvious hinge row, perhaps due to preservation. Three costae pass forward from a spine base over parts of the shell. F 37571 has a few spines along the hinge, umbonal slopes and outer sulcus.

#### Resemblances

These shells were identified with *Marginifera gratiodentalis* (Grabau, 1934) by Coleman (1957). *Productus gratiodentalis* was proposed by Grabau for shells described by Schellwien (1892, p. 24, pl. 3, figs. 6-9; pl. 8, fig. 25) as *Productus gratiosus occidentalis* from the Fusuline beds of the Carnic Alps. Pointing out that the Carnic specimens belonged to a full species distinct from *gratiosus* Waagen, Grabau (1934, p. 36) assigned a new name to Schellwien's species, because *occidentalis* was preoccupied. No type specimen has been designated, but the selection of a lectotype should be deferred until the preservation of Schellwien's figured specimens can be ascertained. Compared with the specimens from Western Australia, they have a more posterior sulcus and finer concentric wrinkles seemingly more restricted to the posterior part of the shell. The radial ornament is much stronger over the anterior inner ears. Schellwien implied through his comparison with *P. gratiosus* Waagen that the Carnic shells are Dictyoclostid, as in Branson (1948, p. 334). It appears unlikely that the Australian shells are in any way related to specimens assigned to *occidentalis* Schellwien or *gratiodentalis* Grabau by Chao (1925, pl. 2, fig. 6; 1927, p. 47, pl. 4, figs. 11-16); Grabau (1934, p. 36, pl. 10, figs. 7-8; 1936, p. 118, pl. 12, figs. 2a-d, 3a, b, 4a, b, 5) and King (1931, p. 71, pl. 14, figs. 1-3). All of these shells are more or less easily distinguished, apparently

lacking halteroid spines, and having finer concentric ornament and a shallow sulcus except in the specimens described by Chao (1925). None of them was compared to *Marginifera*, though the genus was recognised and species described elsewhere by the various authors. Sestini (1965, p. 178, pl. 22, figs. 6, 7) assigned the species to *Marginifera*, but her Karakorum specimen resembles neither the Australian nor European shells.

TABLE 2

Dimensions in mm of *Retimarginifera perforata* n. sp.  
Ventral valves

Width	Length	Height	Umbonal angle	Cardinal angle	Sinal angle	Sinal angle at start of trail
Locality UWA 29401						
26.7	21.6	10		60	23	33
24.3	16.5	11.2	90	75°	20	28°
23	18.4	9.4	95		25	35
29.6	18.7	11	115	55°	22°	40°
27.5	17.5	8.1	102	70	24°	35°
Locality UWA 27185						
20.3	13.9	7.6	110°		25	40°
22.0	11.6	7.8	80	55	25	38°
21.5	13.8	7.4	95		20	35
20.6	12.5	6.6	95		30	35
24	12.6	6.4	112		30°	40°
22.2	13.3	8.3				
24.5	13.8	7.8	112	65°	19°	30°
24.4	13.3	7.7	95	55	28°	38°
Locality WC 20-1						
25.0	16.6	10.6	115	45	15	33°
Dorsal valve UWA 28433a						
Width	Length	Height	Cardinal angle	Fold angle at Anterior	Trail	Septum length
28.4	14.7	8.7	53°	25	40	8.7

Fold angle measured at start of trail and at anterior margin.

Most specimens have lost a little of the cardinal extremities and something of the trail. Septum length shows the distance between the cardinal process and anterior end of the septum.

None of the American species of *Kozlowskia* is particularly close. The type species *Productus capacii* as figured by D'Orbigny (1842, pl. 3, figs. 24-26), Kozlowski (1914, pl. 2, figs. 1-15; pl. 5, fig. 13; text-fig. 1, 2) and Muir-Wood and Cooper (1960, pl. 63, figs. 13-19) is less consistently transverse and more oval in outline, with feeble concentric ornament and less pronounced

TABLE 3

Statistical Summary for *R. perforata*, central valves

	Width	Length	Height	Umbonal angle	Sinal angle
n	14	14	14	12	12
$\bar{x}$	23.9642	15.2928	8.5642	98.83	23.83
s	2.5577	2.8298	1.5309	14.7920	3.9545
V	10.6730	18.5041	17.8756	14.9671	16.5946
$\sigma \bar{x}$	0.6836	0.7563	0.4092	4.2701	1.1416
$r_{width}$		(W) 0.6866	(W) 0.5868	$r_{umb.}$	0.0066

complete specimens only

	8	8	8
n	8	8	8
$\bar{x}$	24.8250	15.6750	9.3000
s	2.2752	3.1063	1.4465
V	9.1649	19.8169	15.5538
$\sigma \bar{x}$	0.8044	1.0982	0.5114
$r_{width}$		0.7791	0.6312

n = number of specimens

 $\bar{x}$  = mean

s = standard deviation

V = coefficient of variation

 $\sigma \bar{x}$  = standard error of the mean $r_{width}$  = correlation coefficient (width —) $r_{umb.}$  = correlation coefficient with umbonal angle.

sulcus and fold. A specimen figured as *P. longispinus* (not Sowerby) by Salter (1861, p. 64, pl. 4, fig. 2) is more elongated, with a moderately well formed sulcus, and emphasized costellae. The scattered tubercles shown over the ventral valve, if they represent spine-bases, would rule out any close alliance, and such also seem to be represented by Kozłowski (1914, pl. 2, fig. 9b) but Kozłowski (1914, p. 22) stated in his text that spines are rare. Specimens examined at the Smithsonian Institution from Apillipampa south of Capinote, Brazil, (USNM 124030a, b; Muir-Wood and Cooper, 1960, pl. 63, figs. 13-19) have 6 halteroid spines, and a few others only. There is no hinge row, perhaps because they have been rubbed off, for the specimens are not well preserved. The ears have been lost from USNM 124030b, but growth lines show that they were large. A small ventral valve kindly made available by Dr. Richard E. Grant from the U.S. Geological Survey, Washington, D.C. has been sectioned. Unfortunately the shell is partly silicified and no taleolae or spine bases can be discerned. Laminations are less pronounced than in the Australian species.

*Marginifera himalayensis* Diener (1899) is also close in shape, but has larger ears and more numerous spines. The types have been examined at the Geological Survey of India, Calcutta. Specimen F 6285 (Diener, 1899, pl. 6, fig. 2) is selected as lectotype. The species seems to have symmetrically disposed halteroid spines, and a row of hinge spines is preserved on some (e.g. F 6236—pl. 2, fig. 2, and F 6238—pl. 2, fig. 4), so that the specimens are not *Marginifera*, but possibly belong to the Paucispiniferinae. It is possibly a new genus, distinguished by the strong concentric ornament of the dorsal valve, and cluster of tubercles or spine bases on the outer ears (as in F 6238), and shell structure. The

shell structure has been examined in specimens collected from the type locality in Kashmir by D. G. Fuchs, Geologische Bundesanstalt, Vienna. The outer shell structure in the ventral valve (Fig. 2, 12) differs considerably from that of *perforata*, coming much closer to that of *Anidanthus* described by Waterhouse (1968a). The innermost band, 0.125 mm thick, consists of parallel prisms perpendicular to the surface, each about 0.13 mm thick. This layer is not preserved in *K. perforata*. The inner secondary layer has cloudy calcite lamellae less conspicuous than in *K. perforata*, but essentially the same in possessing large whorls due to pustules, spaced about 0.4 to 0.6 mm apart in a single row and thus too numerous to have been spine bases. The outer layer, just as thick, has small calcite and matrix filled pores, about 0.1 to 0.05 mm in diameter, possibly due to taleolae, but very obscure. The pores resemble those of *Anidanthus* and *Kuvelousia*, and are much smaller than in *K. perforata*.

*Productus altimontanus* Merla (1934, pl. 20, figs. 27-32, 36-41) and *P. rimuensis* Merla (1934, pl. 24, figs. 7-16, 20) from the Lower Permian of the Karakorum Range are close in outline and ornament, but their spine pattern is not certain. Another externally similar species was described as *Marginifera hoofti* Renz (1940, p. 27, pl. 4, figs. 12a-c) from Upper Uralian beds of locality 5, Shukpa Kuchang Glacier, of the Karakorum. Unfortunately its spinose ornament has not been described, but the illustrated specimen resembles the new form in outline and ornament. "*Marginifera*" *pusilla* Schellwien (1892, pl. 4, figs. 11-21) has a few large halteroid spines in a concentric row, and strong radial ornament and large ears, and so probably belongs to the same plexus as the new form. It came from the Auernigg beds of east Europe. Concentric ornament is less defined.

*Marginifera reticulata* King (1931, pl. 22, figs. 3, 10) might also prove to be allied. It comes from the Leonard of the Glass Mountains, and has similar ornament and deep sulcus, but is slightly more rectangular in outline, with smaller ears and longer visceral disc.

### Acknowledgements

Dr. P. J. Coleman, Department of Geology, University of Western Australia, Perth, lent specimens identified as *Marginifera gratiodentalis* from Western Australia, and Dr. Gerhard Fuchs, Geologische Bundesanstalt, Vienna, sent specimens of "*Productus*" *himalayense* from Kashmir.

Particular thanks are due to Dr. G. A. Cooper, Smithsonian Institution, U.S. National Museum, Washington for his help in guiding me through collections and types in his care. Drs. C. MacClintock and A. L. McAlester facilitated examination of relevant types at the Peabody Museum, Yale University and Messrs M. V. Sastry and S. C. Shah provided facilities for examining types at the Geological Survey of India, Calcutta. Dr. R. E. Grant, U.S. Geological Survey, Washington, D.C. gave specimens of *Kozłowskia capacii* for sectioning.

## References

- Branson, C. (1948).—Bibliographic Index of Permian Invertebrates. *Geol. Soc. Amer. Mem.* 26: 1050 pp.
- Chao, Y. T. (1925).—On the age of the Taiyuan Series of North China. *Bull. Geol. Soc. China* 4, (1): 221-49.
- (1927).—Productidae of China Pt 1: Producti. *Palaeont. Sinica ser. B* 5, (2): 1-244, 16 pls., 7 text figs.
- Coleman, P. J. (1957).—Permian Productacea of Western Australia. *Bur. Mineral Resour. Geol. Geophys. Bull.* 40: 1-189, 19 pls.
- Condon, M. A. (1954).—Progress report on the stratigraphy and structure of the Carnarvon Basin, Western Australia. *Bur. Mineral Resour. Aust. Rep.* 15: 1-163.
- (1967).—The Geology of the Carnarvon Basin, Western Australia Part 2: Permian stratigraphy. *Bur. Mineral Res. Geol. Geophys. Bull.* 77: 1-191.
- Cooper, G. A. and Grant, R. E. (1964).—New Permian stratigraphy units in Glass Mountains, west Texas. *Amer. Assoc. Petrol. Geol. Bull.* 48(9): 1531-1588, 2 figs.
- (1966).—Permian rock units in the Glass Mountains, West Texas. *Bull. U.S. Geol. Surv.* 1244 E: E1-9.
- Dickins, J. M. (1956).—Permian pelecypods from the Carnarvon Basin, Western Australia. *Bur. Mineral Resour. Geol. Geophys. Bull. Austr.:* 29.
- (1963).—Permian pelecypods and gastropods from Western Australia. *Bur. Mineral Resour. Geol. Geophys. Bull. Aust.* 63: 1-202.
- Diener, C. (1899).—Anthracolithic fossils of Kashmir and Spiti. *Palaeont. Indica ser.* 15, (2).
- D'Orbigny, A. (1842).—Voyages dans l'Amerique meridionale. Vol. 3, pt. 4: Paléontologie. P. Bertrand, Paris.
- Frederiks, G. (1933).—Palaeontological Notes 4. On some upper Paleozoic Brachiopods of Eurasia. *Mater. Cent. Sci. Geol. Prospect. Inst.* 2: 24-33 (in Russian with English summary).
- Furnish, W. M. (1966).—Ammonoids of the Upper Permian *Cyclolobus* Zone. *N. Jb. Geol. Paläont. Abh.* 125: 265-296.
- Glenister, Brian F. and Furnish, W. M. (1961).—The Permian Ammonoids of Australia. *J. Paleont.* 35(4): 673-736, pls. 78-86, 17 text figs.
- Grabau, A. W. (1934).—Early Permian fossils of China. 1: Early Permian brachiopods, pelecypods and gastropods of Kueichow. *Palaeont. Sinica B v.* 8: pt. 3.
- (1936).—Early Lower Permian fossils of China. Pt. 2. Fauna of the Maping Limestone of Kwangsi and Kweichow. *Paleont. Sinica B v.* 8: pt. 4.
- King, R. E. (1931).—The Geology of the Glass Mountains, Texas. Pt 2. *Univ. Texas Bull.* 3042: 1-150, 44 pls.
- Kozłowski, R. (1914).—Les brachiopodes du carbonifère supérieur de Bolivie. *Annales de Paleont Paris* 9(1): 1-100.
- Licharev, B. K. (1959).—On the boundaries and principal divisions of the Permian System. *Sov. Geol.* 1959(6): 13-30.
- (1966).—The Permian System. Stratigraphy of USSR, Moscow. 536 pp. 62 figs. 20 tables.
- Merla, G. (1934).—Fossili anthracolitici del Caracorum. *Sped. ital. De Filippi nell' Himalaia Caracorum e Turchestan Cinese 1913-1914*, Ser. 2, 5: 101-319, Bologna.
- Muir-Wood, H. M. (1965).—Productidina. In *Brachiopoda. Treatise on Invertebrate Paleontology Part H, 1, 2*: 439-510; Addendum: 903-5.
- and Cooper, G. A. (1960).—Morphology, Classification and Life Habits of the Productoidea (Brachiopoda). *Geol. Soc. Amer. Mem.* 81: 1-447, 135 pls., 8 text figs.
- Nassichuk, S. S., Furnish, W. M. and Glenister, B. F. (1965).—The Permian Ammonoids of Arctic Canada. *Canada Geol. Surv. Bull.* 131: 1-56, pls. 1-5.
- Prendergast, K. L. (1943).—Permian Productinae and Strophalosiinae of Western Australia. *J. Roy. Soc. W. Aust.* 28: 1-73.
- Renz, C. (1940).—Die Paläozoischen Faunen von 1929-30. *Wissenschaftliche Ergebnisse der Niederländische Expedition in dem Karakorum*, 3(1): *Geologie Abt.* 1: 9-68. E. J. Brill, Leyden.
- Ruzencev, V. E. (1956).—Lower Permian Ammonites of the southern Urals 11. Ammonites of the Artinskian Stage. *Trud. Paleont. Inst. Akad. Nauk SSSR* 60: 1-275, pls. 1-39.
- Salter, J. W. (1861).—On the fossils, from the high Andes, collected by David Forbes, Esq. *Quart. J. Geol. Soc. Lond.* 17: 62-73.
- Schellwien, E. (1892).—Die fauna des Karnischen Fusulinenkalks. *Paläontographica B* 39: 91-136.
- Sestini, N. F. (1965).—Permian Fossils of the Shaks-gam Valley, Ital. Exped. Karakorum (K2) and Hindu Kush. *Sci. Rep. IV Paleont. Zool. Bot.* 4: 149-215, pls. 2-24. E. J. Brill, Leyden.
- Stehli, F. G. (1954).—Lower Leonardian Brachiopods of the Sierra Diablo. *Bull. Amer. Mus. Nat. Hist.* 105(3): 261-358, pls. 17-27, 55 text figs.
- Teichert, C. (1950).—Some recent additions to the stratigraphy of Western Australia. *Bull. Amer. Assoc. Petrol. Geol.* 34(9): 1781-1794.
- (1957).—Notes on the Geology of the Carnarvon (Northwest) Basin, Western Australia. *J. Roy. Soc. W. Aust.* 40(2): 65-72.
- Thomas, G. A. and Dickins, J. M. (1954).—Correlation and age of the marine Permian formations of Western Australia. *Aust. J. Sci.* 16(6): 219-23.
- Waterhouse, J. B. (1958).—The Age of the Takitimu Group of Western Southland. *N.Z.J. Geol. Geophys.* 1: 604-10.
- (1964).—Permian stratigraphy and faunas of New Zealand. *N.Z. Geol. Surv. Bull.* 72: 1-101.
- (1967).—Proposal of Series and Stages for the Permian of New Zealand. *Trans. Roy. Soc. N.Z. Geol.* 5, (6): 161-180.
- (1968a).—Redescription of the Permian brachiopod *Anidanthus springsurensis* Booker. *Trans. Roy. Soc. N.Z. Geol.* 5(10): 235-343, 1 pl.
- (1968b).—New species of *Megousia* Muir-Wood and Cooper and allied new genus from the Permian of Australia and North America. *J. Paleont.* 42(5): 1171-1185, pls. 154-156.
- (1969a).—The Palaeoclimatic Significance of Permian Productacea from Queensland. *Stratigraphy and Palaeontology: Essays in Honour of Dorothy Hill*, 226-235, figs 40-43. A.N.U. Press, Canberra.
- (1969b).—Chronostratigraphy for the marine world Permian. *N.Z. J. Geol. Geophys.* 12: 842-848.
- (1970).—Gondwanan occurrences of the upper Paleozoic brachiopod *Stepanoviella*. *J. Paleont.* 44 pt. 1: 37-50.

## INSTRUCTIONS TO AUTHORS

Contributions to this Journal should be sent to *The Honorary Secretary, Royal Society of Western Australia, Western Australian Museum, Perth*. Papers are received only from, or by communication through, Members of the Society. The Council decides whether any contribution will be accepted for publication. All papers accepted must be read either in full or in abstract or be tabled at an ordinary meeting before publication.

Papers should be accompanied by a table of contents, on a separate sheet, showing clearly the status of all headings; this will not necessarily be published. Authors should maintain a proper balance between length and substance, and papers longer than 10,000 words would need to be of exceptional importance to be considered for publication. The Abstract (which will probably be read more than any other part of the paper) should not be an expanded title, but should include the main substance of the paper in a condensed form.

Typescripts should be double-spaced on opaque white foolscap paper; the original and one carbon copy should be sent. All Tables, and captions for Figures, should be on separate sheets. Authors are advised to use recent issues of the Journal as a guide to the general format of their papers, including the preparation of references; journal titles in references may be given in full or may follow any widely used conventional system of abbreviation.

Note that *all* illustrations are Figures, which are numbered in a single sequence. In composite Figures, made up of several photographs or diagrams, each of these should be designated by letter (e.g. Figure 13B). Illustrations should include all necessary lettering, and must be suitable for direct photographic reproduction. To avoid unnecessary handling of the original illustrations, which are usually best prepared between  $1\frac{1}{2}$  and 2 times the required size, authors are advised to supply extra prints already reduced. Additional printing costs, such as those for folding maps or colour blocks, will normally be charged to authors.

It is the responsibility of authors to adhere to the International Rules of Botanical and Zoological Nomenclature. Palaeontological papers must follow the appropriate rules for zoology or botany, and all new stratigraphic names must have been previously approved by the Stratigraphic Nomenclature Committee of the Geological Society of Australia.

Thirty reprints are supplied to authors free of charge, up to a maximum of 60 for any one paper. Further reprints may be ordered at cost, provided that orders are submitted with the returned galley proofs.

Authors are solely responsible for the accuracy of all information in their papers, and for any opinion they express.

**Journal**  
**of the**  
**Royal Society of Western Australia**

Volume 53

1970

Part 4

**Contents**

10. The Australian Majid spider crabs of the genus *Achaeus* (Crustacea, Brachyura). By D. J. G. Griffin.
11. Permian Brachyopod *Retimarginifera* n. gen. n. sp. from the Byro Group of Carnarvon Basin, Western Australia. By J. B. Waterhouse.



Editor: A. S. George

Assistant Editor: W. A. Loneragan

The Royal Society of Western Australia, Western Australian Museum, Perth